3 March 1966

PHASE I, DESIGN

# PORTABLE PROTOTYPE TUBE FLARE INSPECTION INSTRUMENT

Contract NAS 8-20516

Prepared for:

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
George C. Marshall Space Flight Center
Huntsville, Alabama

FACILITY FORM 602

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Prepared by:

METROPHYSICS, Inc.
331 North Milpas Street
Santa Barbara, California

3 March 1966

PROGRESS REPORT - PHASE I, DESIGN

Portable Prototype Tube Flare Inspection Instrument
Contract NAS 8-20516

INTRODUCTION:

This report is in compliance with NASA Contract NAS 8-20516, "Portable Tube Flare Inspection Instrument", awarded to METRO-PHYSICS, Inc., and covers the design phase for the development of this instrument.

The design work covers the period of 1 July 1965 through 1 December 1965, and includes circuit design, mechanical design, probe and fixture design, and breadboarding to prove design feasibility. These objectives have been met successfully, and work is proceeding on fabrication and documentation.

CIRCUIT DESIGN:

The approach made to the electronics design was one which would afford the greatest possible flexibility in operator selection of dimensions and yet not detract from the capabilities of the mechanical system.

The selection of a design for a commutator was the first task undertaken. It was considered necessary that the commutator have a reasonably high input impedance, offer negligible degradation to the input signal, be capable of finite selection of channels, and introduce no noise or crosstalk. A solid-state commutator design

was selected which utilizes new "P" channel field effect transistor as the switching element. The driver elements were selected from the same manufacturer of the FET switch to assure good compatability between these elements. A "shift register" counter configuration was selected for scanning with a decoding scheme sometimes referred to as a "Johnson counter". Two of these Johnson counters are used - one for angle measurements, and one for diameter measurements. The FET switches are arranged in a matrix array such that one counter is used for vertical scanning - angle measurements and the other counter is used for horizontal scanning - diameter measurements. The commutator is made up of eleven (11) 6 x 5-1/2 inch interchangeable printed circuit boards, each containing 12 FET switches and 12 NAND gate drivers. Each circuit board represents one ring of 12 sensors located in the gauge. The gauge has a total of 132 active sensors requiring the use of a 132 channel commutator. Figure 1 is a schematic of the final design for the commutator circuit board, showing 12 of the 132 FET switches, $Q_1$ through $Q_{12}$, and their respective NAND gate drivers. These NAND gates are a special design for this application by MP/I. Design of the commutator was finalized in the latter half of September 1965 after breadboard tests with the FET matrix and Johnson counter were completed.

The task of selecting display modes by manual front panel controls was approached from the standpoint of simplicity of display and ease of operation. Keyboard control switches manufactured by Mirco-Switch Co. normally for computer control panels

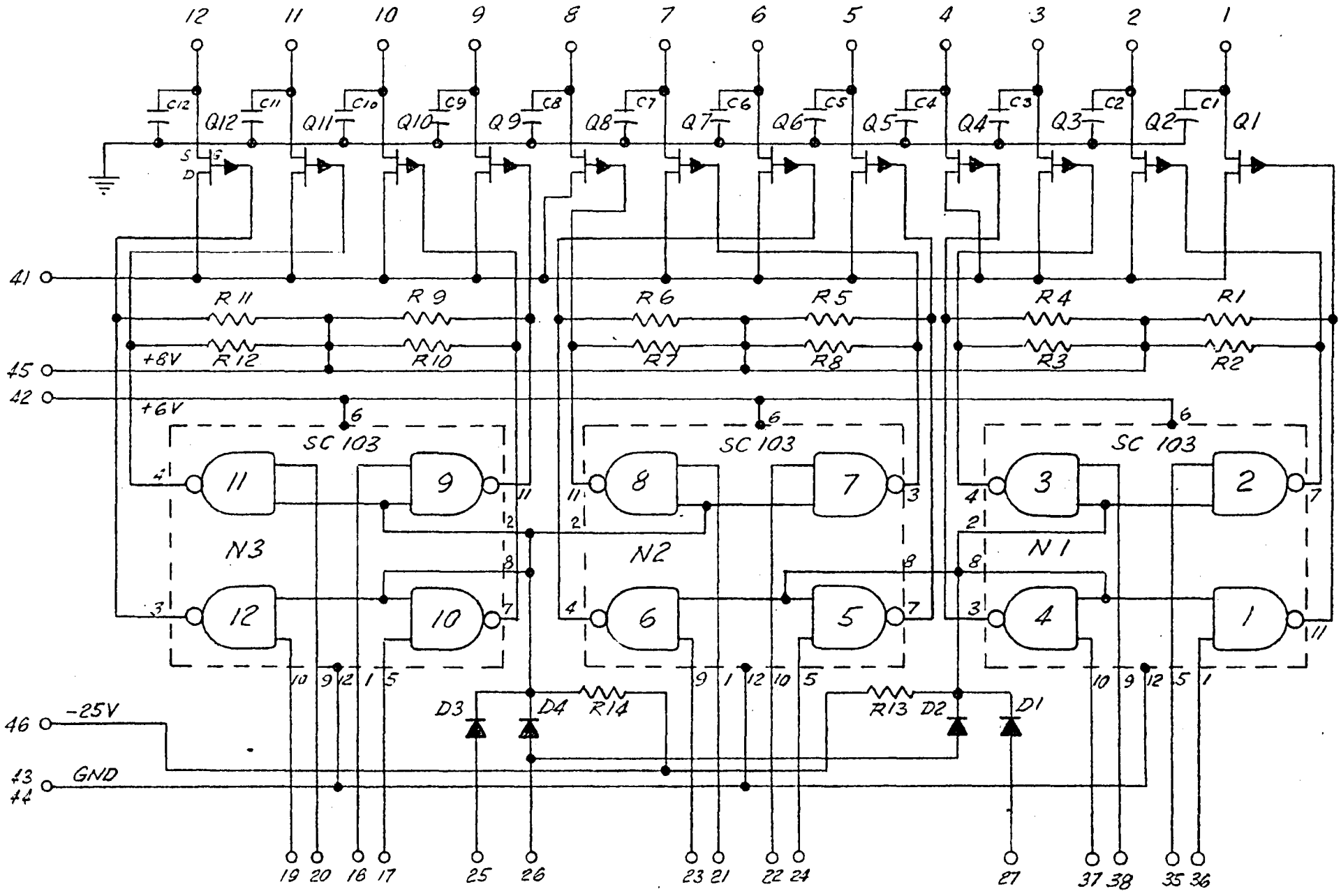



FIGURE 1

COMMUTATOR CIRCUIT BOARD

were selected. These switches illuminate when depressed and are interlocked to prevent incorrect mode selection. They have high reliability, long life and fit our application nicely. A "record" switch and capability has been incorporated into the system. This is an additional feature not originally planned. When this switch is depressed, the scanning or sampling rate is decreased from 600 samples per sec. to 1 sample per sec. which is slow enough to be recorded on an inexpensive analog recorder through output jacks located at the right side of the switch.

The signal conditioner shown at the botton of Figure 2, and in the enclosed Layout Drawing No. 100818, is considered a part of the probe gauge assembly. It consists of 135 each 1 K ohm potentiometers, one for each dimension sensing photo diode and three for the three diodes used for light regulation. Once a signal conditioner is adjusted or calibrated with a particular gauge, that gauge/conditioner combination may be connected and disconnected without influencing the calibration accuracy of the system, thereby making the tube flare inspection rack and 25 ft. connecting cable adaptable to any number of gauges. The signal conditioner for the 3/4 inch gauge has been fabricated, and is ready to be wired up when the gauge is completed.

Compensation for changes in incident light intensity and variations in reflected light due to different surface finishes was readily accomplished by taking advantage of the flat portion of the light vs. diode/fiber optics output response curve. Fiber optics bundles, one each for each of the three lamps, are recessed

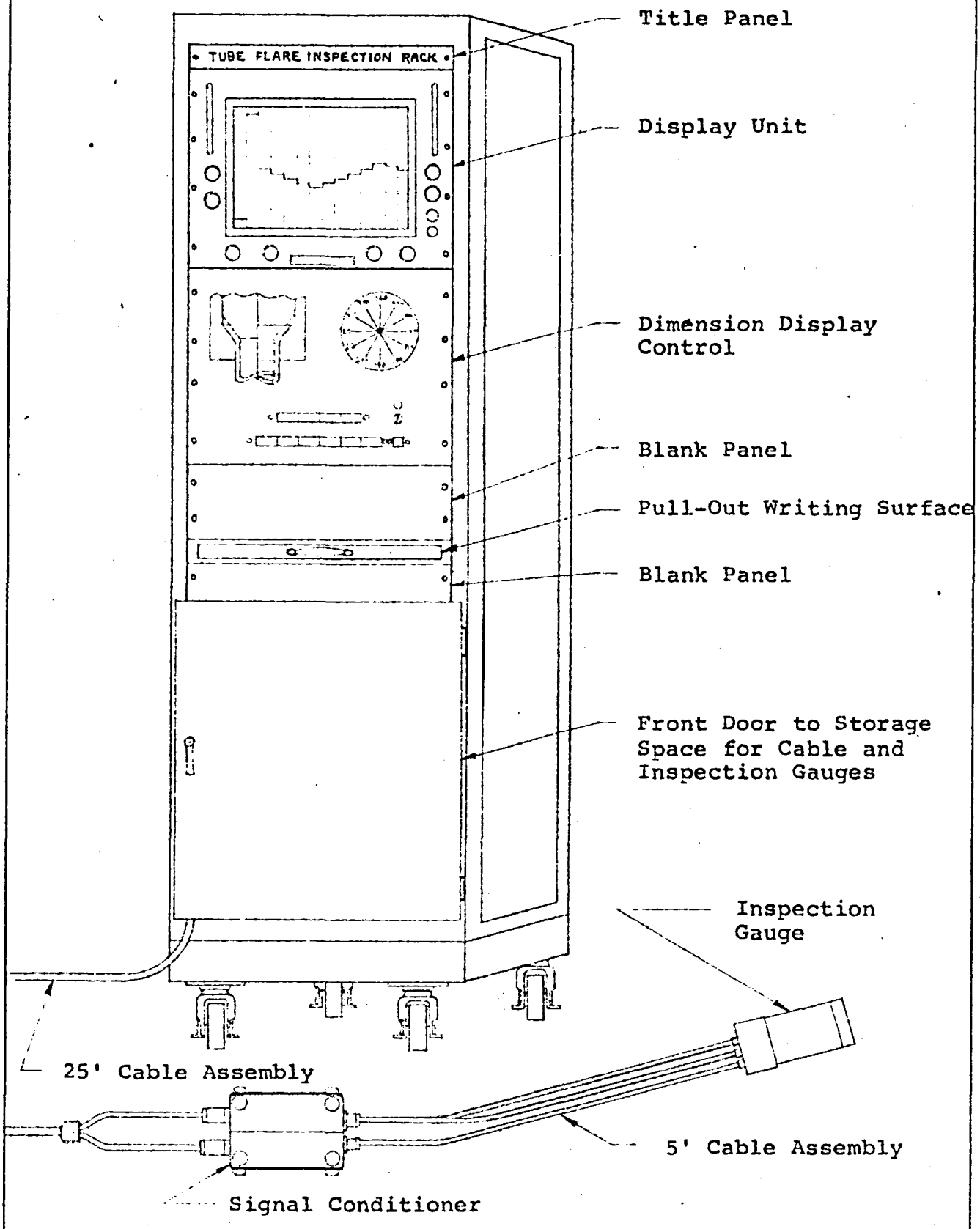



FIGURE 2 - Tube Flare Inspection Rack

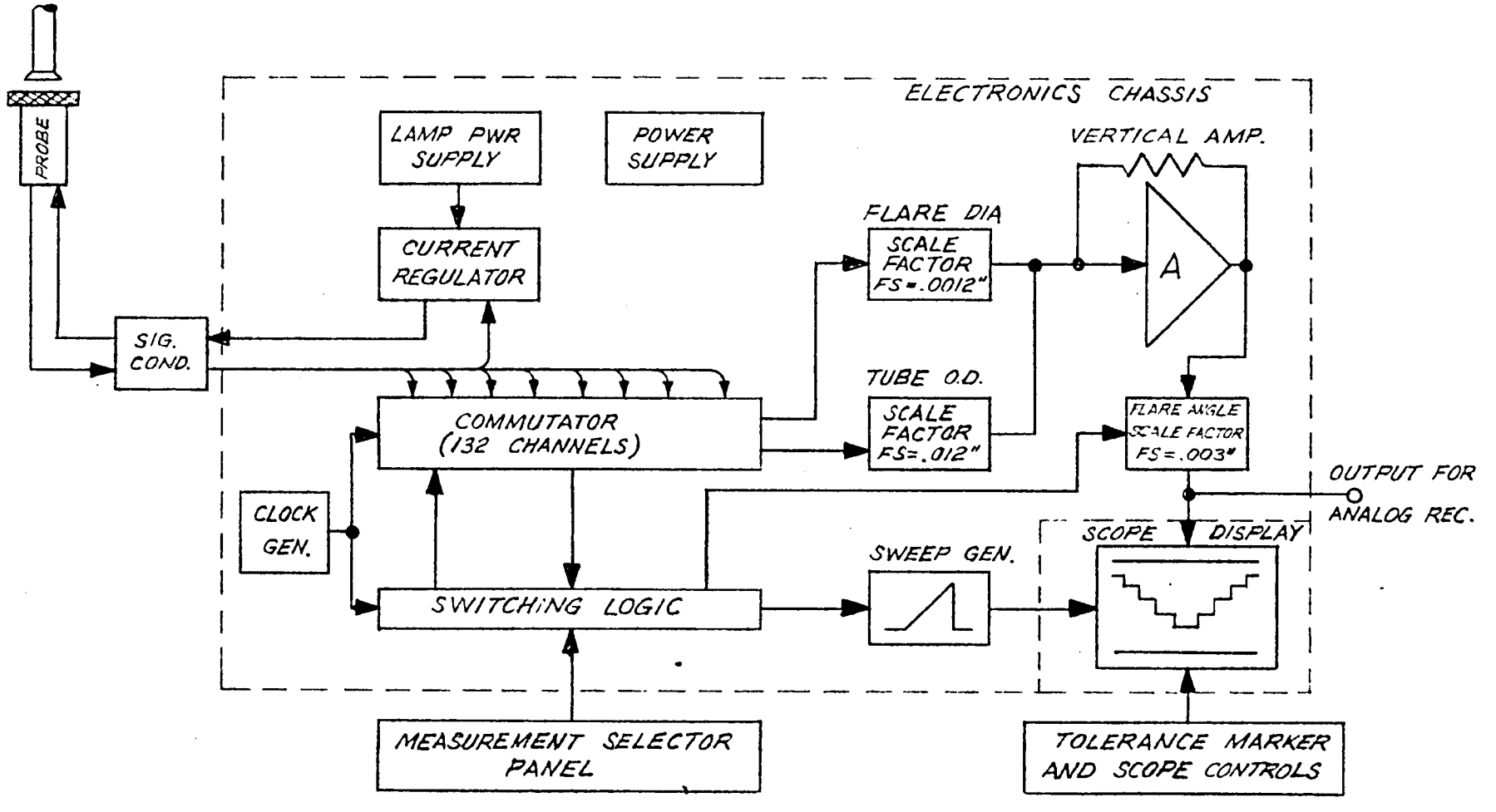
a certain amount into the wall of the gauge to insure a minimum flare surface to optics distance. At this distance the diode output is no longer responsive (within limits) to distance, but rather only to the light intensity which now is proportional to the variations mentioned. The diode outputs of these three sensors are used to control current regulators for the lamp power supplies, thereby controlling the lamp light outputs.

Figure 3 is a block diagram of the system. All of the subassemblies of the electronics system have been designed and checked out in breadboard models.

MECHANICAL DESIGN

Figure 2 shows the final configuration of the console. All hardware required to make up the equipment represented in this figure has been received or is on order. A photograph of this scope display was taken showing the adjustable limit markers, and is enclosed with this report. The information-channels displayed in the photo are not a true representation of the 12-channel system, but rather a repetition of a 4-channel breadboard system. It does, however, give an idea of the quality of the display.

A design for the electronics chassis and a selection for the console was ready at the end of November. On 9 December 1965, a visit to MP/I was made by Messrs. R. W. Lochridge and F. L. Hendrix of NASA concerning documentation requirements under this contract. At their suggestion, it was decided that the chassis and console requirements would be served better by using a standard NASA chassis design and a console of the type most used to house other




BLOCK DIAGRAM – TUBE FLARE INSTRUMENT
FIGURE 3

MEDRAD ANALYSIS INC.

NASA systems. A redesign was then undertaken to meet this decision. Layout drawings of the signal conditioner (No. 100818) and the electronics chassis (No. 100954) are enclosed with this report.

PROBE AND FIXTURE DESIGN:

The first design drawings for the probe gauge fixture received from our subcontractor - Mechanical Technology, Inc. - were unsatisfactory in several respects. Examples of some of the questionable areas are as follows:

1. Housing too long - limited flare to first bend length to 5 inches; specification requirement is 1-3/4 inches.
2. No means provided to limit force applied to the flare when applying the gauge fixture.
3. Bearing length to diameter ratio too large on certain gauge elements. This could cause a "cocking" effect when mating the parts.
4. Accessibility for lamp replacement not adequate.
5. Gauge was not adaptable to both the "thin" and "thick" wall tubing.

These and other problems were discussed at length with Mechanical Technology, Inc. and Mr. Wallace Jordan of Marshall Space Flight Center during his visit to the MP/I facility. A sketch showing Mr. Jordan's and MP/I's recommendations to correct these discrepancies was forwarded to Mechanical Technology, Inc. They concurred with our findings and agreed to incorporate the recommended changes. A copy of the MP/I sketch, No. 100953, is included with this report. The sketch indicates the use of six sensing

rings as originally planned. Mechanical Technology, Inc. advised that it would be difficult and risky to attempt to provide a six ring gauge at this time because of fabrication problems involved. Six rings would require a density of fiber optics and machining above what they consider to be a comfortable safety margin.

The problem regarding the gauge's capability to measure both "thin" and "thick" walled tubing was solved by compromise. Rather than lose information from two rings when centering the inside rings on a thin wall flare, it was decided to offset the inside rings down a certain amount so that one ring, the lower one, is just off the flare surface and the four upper rings are in proper position for total flare measurement. In this manner, both "thick" and "thin" walled tubing will be measured with four of the five rings - the upper ring being lost for thick wall tubing measurement in the same manner as was the lower ring for thin wall measurement.

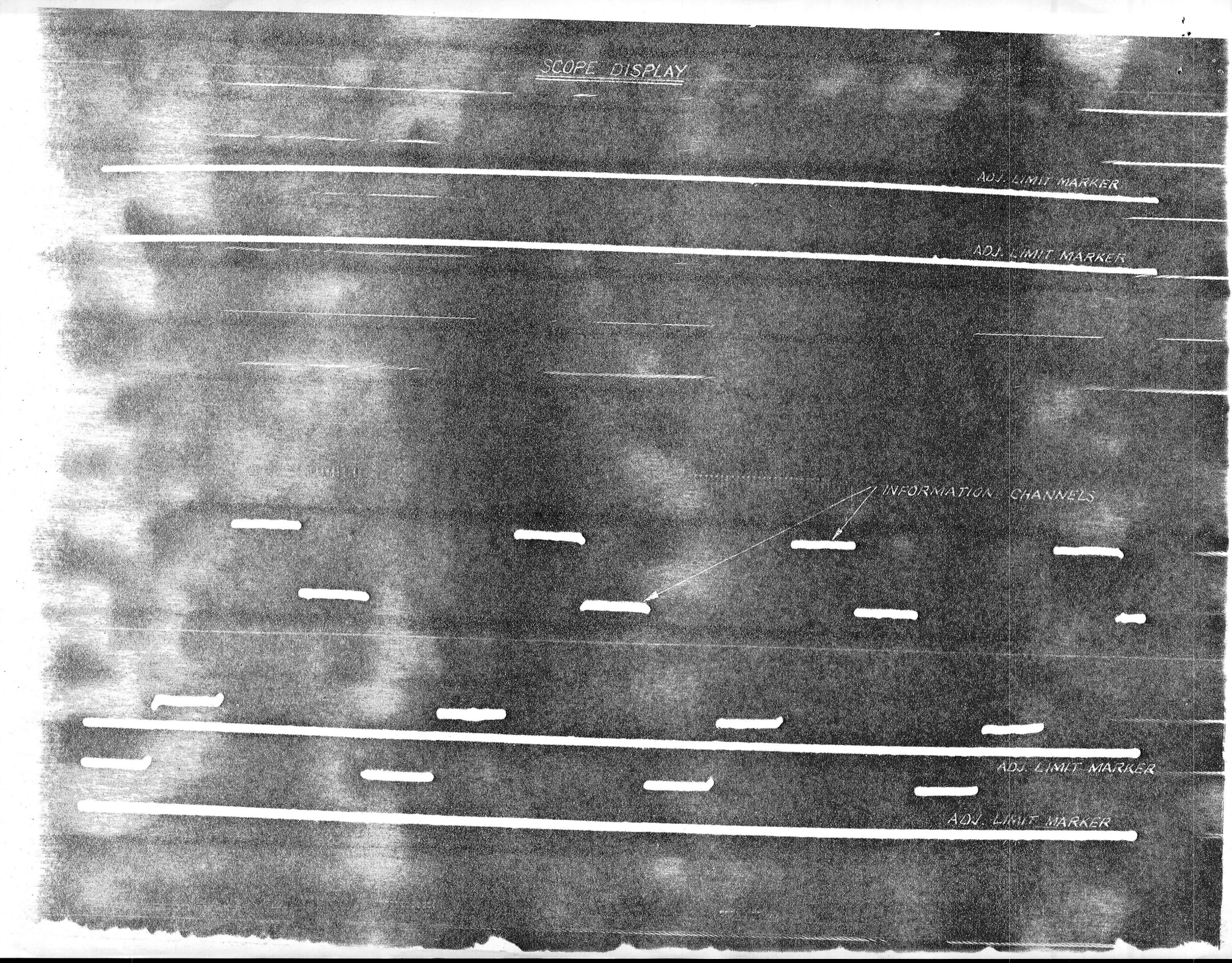
BREADBOARDING:

A breadboard of the commutator and switching circuitry was fabricated, based on a 2 x 4 matrix which represents the 10 x 12 matrix (10 rings, 12 sensors per ring) planned for the final system. This and other breadboards were installed in a mechanical mockup of the console, along with power supplies and display scope. Tests were conducted, using different sweep speeds and switching configurations to help decide on optimum parameters. Tests also were conducted to determine the amounts of noise, crosstalk and other undesirable effects which could be produced by the 25 foot cable. No troubles were noted that would indicate a possible problem with the final system.

SUMMARY:

In summarizing activities over the five month reporting period it can be said that all design objectives have been met successfully with no major design problems being encountered. Based on the results of Phase I, Phase II, Fabrication, was initiated on schedule with documentation keeping pace with these activities.

MP/I has been able to design into the electronics of this system a flexibility which makes it quite adaptable to other applications. The electrical signals involved lend themselves well to electronic manipulation and display. A varity of recording techniques and devices are readily adaptable to the system for obtaining permanent statistical data. Experience is showing that the dimensional measurement accuracies afforded by this technique of precision measuring using fiber optics are unattainable by any other means without the use of elaborate equipment and painstaking and time consuming procedures.


SCOPE DISPLAY
ADJ. LIMIT MARKER
ADJ. LIMIT MARKER
INFORMATION CHANNELS
ADJ. LIMIT MARKER
ADJ. LIMIT MARKER

METROPHYSICS INC.

6 May 1966

A-D-D-E-N-D-U-M

PHASE I, DESIGN PROGRESS REPORT

PORTABLE PROTOTYPE TUBE
FLARE INSPECTION INSTRUMENT

Contract NAS 8-20516

Prepared for:

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
George C. Marshall Space Flight Center
Huntsville, Alabama

Prepared by:

METROPHYSICS, Inc.
331 N. Milpas Street
Santa Barbara, California

SQ7-38719

JUL 7 1966

ADDENDUM:

This addendum is intended to include such information and changes necessary to correct deficiencies noted in PHASE I, DESIGN PROGRESS REPORT submitted to National Aeronautics and Space Administration, Marshall Space Flight Center, on 3 March 1966 under contract NAS 8-20516, "Portable Prototype Tube Flare Inspection Instrument", and is comprised of the following.

1. Description of deficiencies and corrections
2. Advanced Electrical Schematic, "Tube Flare Inspection Instrument", 1 copy - 16 sheets
3. Mechanical Technology, Inc. Drawing No. 1080-F-002, "3/4 Inch Gage Fixture", 1 copy - 1 sheet
4. MP/I Dwg No. 100954, "Layout - Electronics Chassis", 1 copy - 1 sheet

The deficiencies and the respective corrections made by MP/I to relieve these deficiencies are as follows:

Deficiency:

Complete electrical system schematics are required to define the design.

Correction:

"Advanced Electrical Schematic, Tube Flare Inspection Instrument", comprising 16 sheets is herewith submitted. Attached to Sheet 1 of this schematic are copies of vendor schematics of two off-the-shelf PCB's used in the design. This schematic package represents the complete electrical design of the system, with the exception of two power supplies, PS615 and PS616, purchased from

Modular Devices, Inglewood, California. Schematics of these power supplies are not in reproducible form at this time, but will be included in the formal documentation package.

Deficiency:

The report should include the final sketch layout of the gauge head.

Correction:

One copy of Mechanical Technology Drawing No. 1080-F-002, "3/4 Inch Gauge Fixture", is herewith submitted.

Deficiency:

The dimension selector switches do not include the 0/180° location.

Correction:

This correction has been incorporated into MP/I Dwg No. 100954,"Layout, Electronic Chassis". One copy of the corrected drawing is herewith submitted.

Deficiency:

The power switch and indicator light should be on the left of the chassis panel per MSFC Human Engineering Specification.

Correction:

The power switch and indicator light have been re-located to the left of the chassis panel. This change is reflected in Layout Dwg No. 100954.

Addendum Page 3

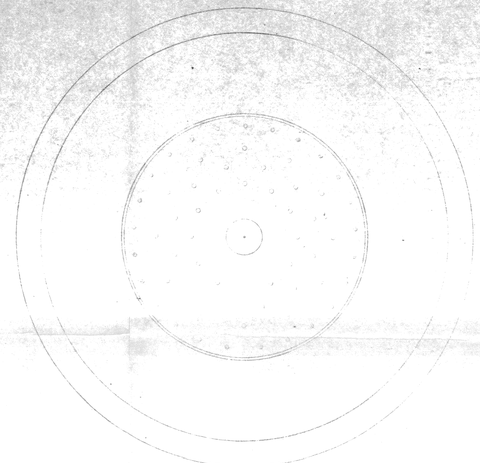
Deficiency:

A design of the flare configuration and dimensional locations should be included.

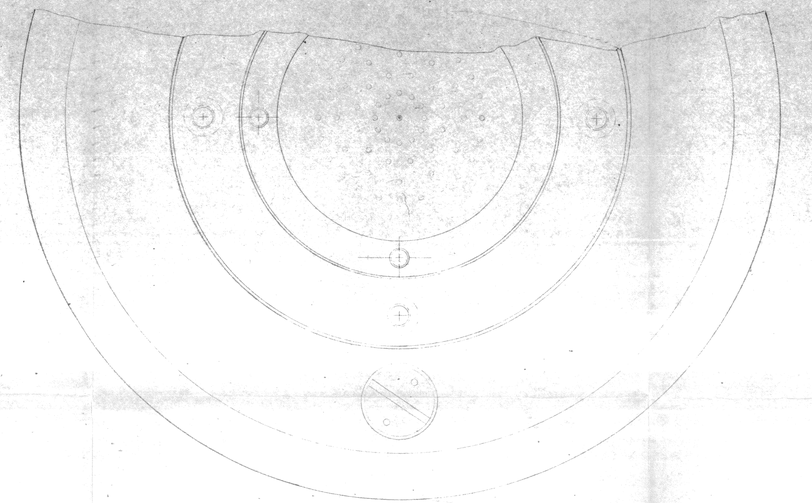
Correction:

Layout Drawing No. 100954 has been revised to show the Dimensional Orientation Display.

The MP/I Phase I, Progress Report with this Addendum is subject to approval by MSFC Contracting Officer under Contract NAS 8-20516. Subsequent Progress Reports provided for under this contract will be submitted in such detail as to alleviate any future necessity for addenda or revisions.



SECTION A-A



SECTION B-B
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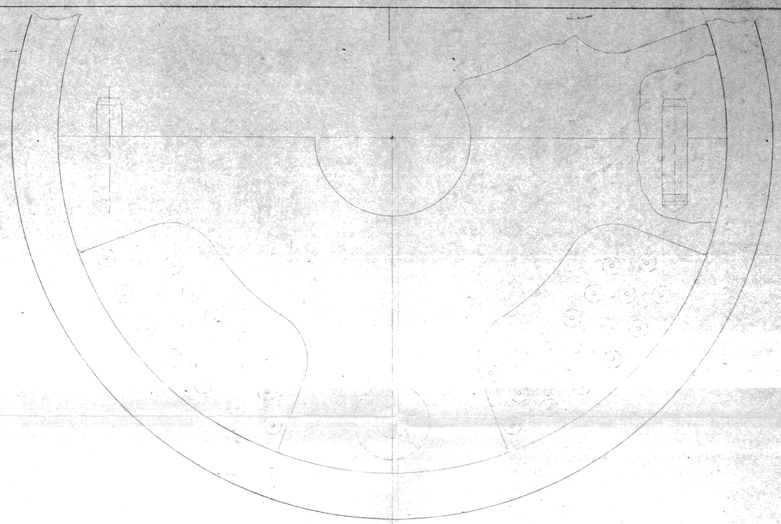

SECTION C-C
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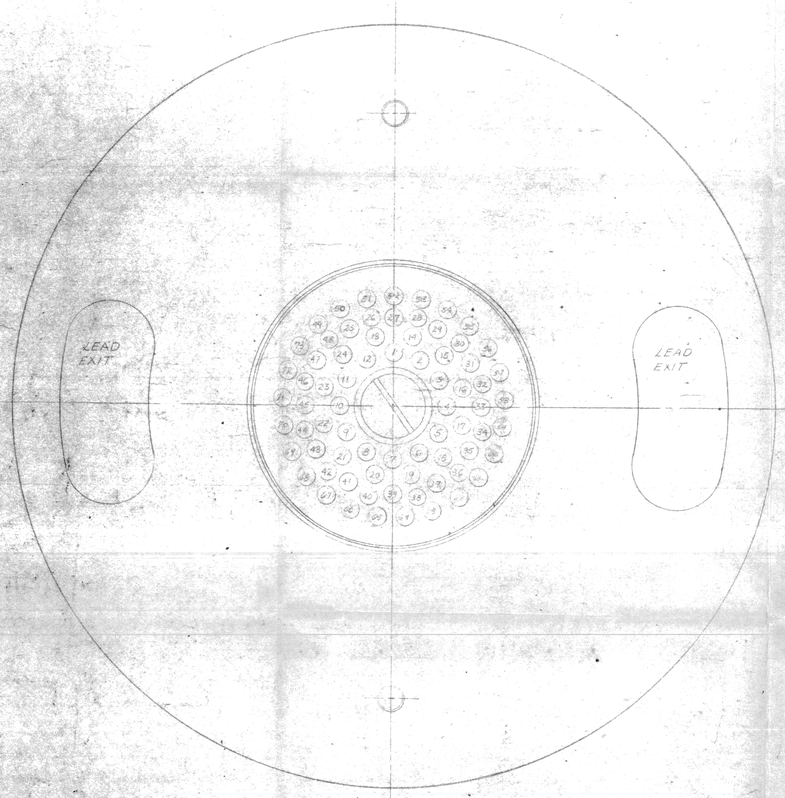


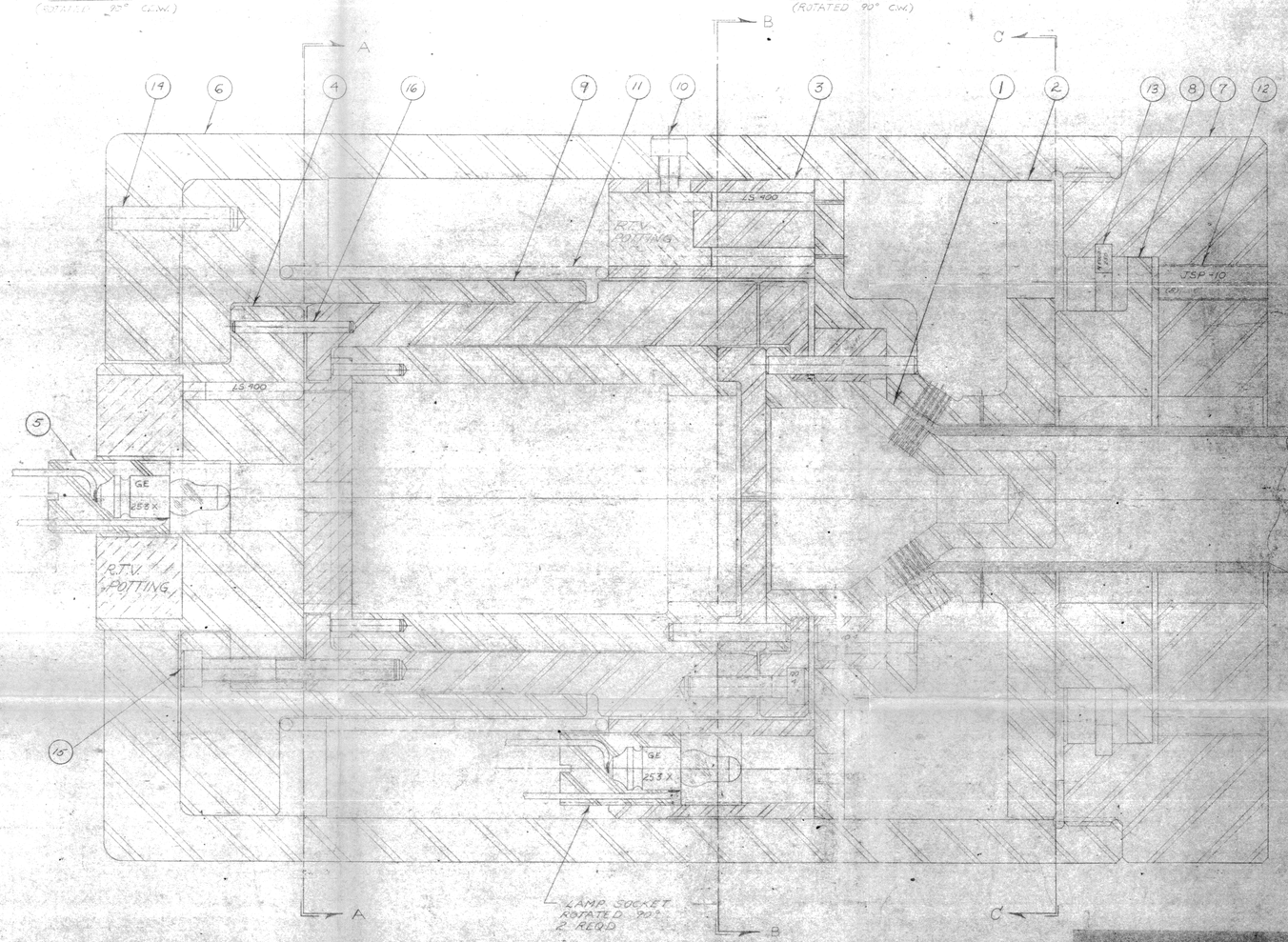


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BILL OF MATERIAL

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R. P. HOFFEL Division of MECHANICAL INDUSTRY INCORPORATED Buffalo, New York

DRAWN R. [illegible] 11/16
DESIGNED
CHECKED

MACHINE [illegible]
MAT'L 3/4 GLASS FIBRE

FOR LAYOUT ASSEMBLY

SCALE 1 = 1

DRAWING NO. 291 5-102

JUL 7 1966

ANGLE SECTIONS




DIMENSION DISPLAY CONTROL

RECEPTACLE BRACKET







PRINTED CIRCUIT BOARDS & RACK







LAYOUT, ELECTRONIC CHASSIS 100954

JUL 7 1966

SCALE 1/1

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# ADVANCED ELECTRICAL SCHEMATIC


| SHEET NO. | TITLE |
|---|---|
| 1 | INDEX & NOTES |
| 2 | INTERCONNECTIONS CB 1 THRU CB 11 |
| 3 | INTERCONNECTIONS CB 1 THRU CB 12 |
| 4 | INTERCONNECTIONS CB 1 THRU CB 11 |
| 5 | INTERCONNECTIONS CB 12 THRU CB 15 |
| 6 | INTERCONNECTIONS CB 16 THRU CB 19 |
| 7 | INTERCONNECTIONS CB 20 THRU CB25 & PWR SUPPLIES |
| 8 | DISPLAY CONTROL SWITCHES |
| 9 | COMMUTATOR PCB CB 1 THRU CB 11 |
| 10 | OR GATE PCB CB 16 |
| 11 | AMPLIFIER PCB CB 20 |
| 12 | LAMP REGULATOR CB 22 & CB 24 |
| 13 | SIGNAL CONDITIONER & SENSORS, INSIDE FLARE |
| 14 | SIGNAL CONDITIONER & SENSORS, INSIDE FLARE |
| 15 | SIGNAL CONDITIONER & SENSORS, OUTSIDE FLARE |
| 16 | SIGNAL CONDITIONER & SENSORS, OUTSIDE FLARE |


## NOTES

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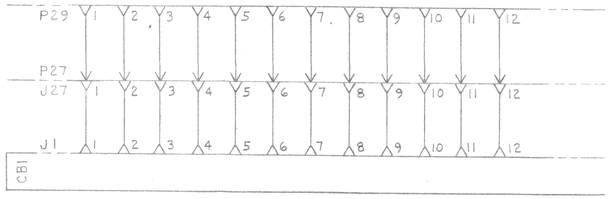


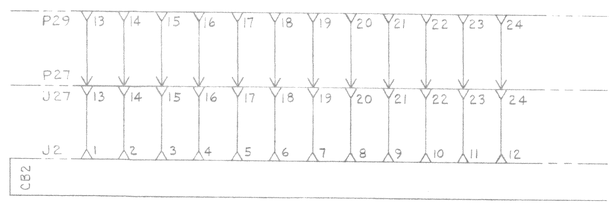


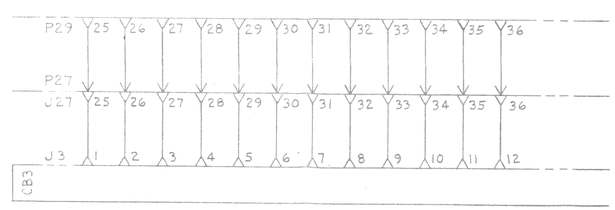


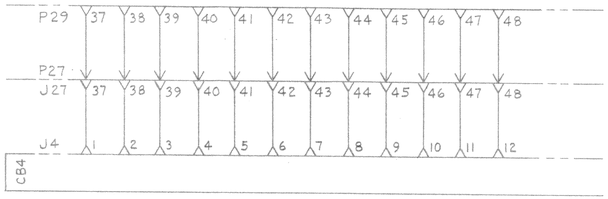


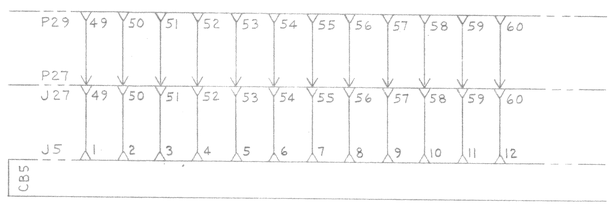


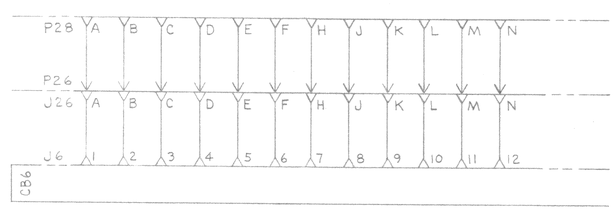


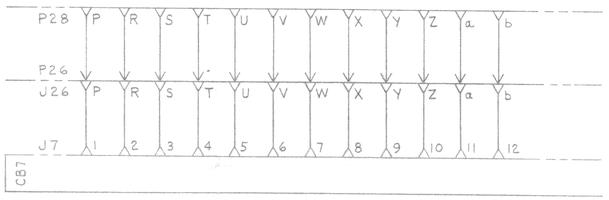


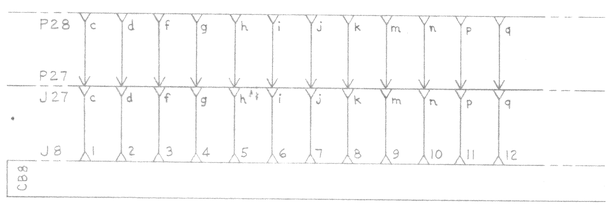


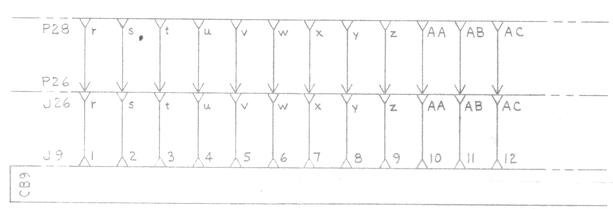


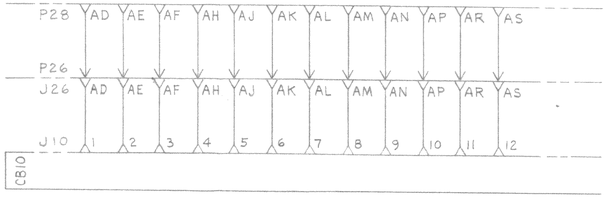


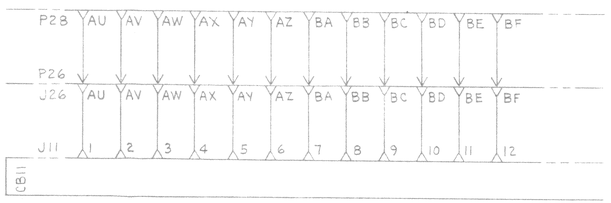


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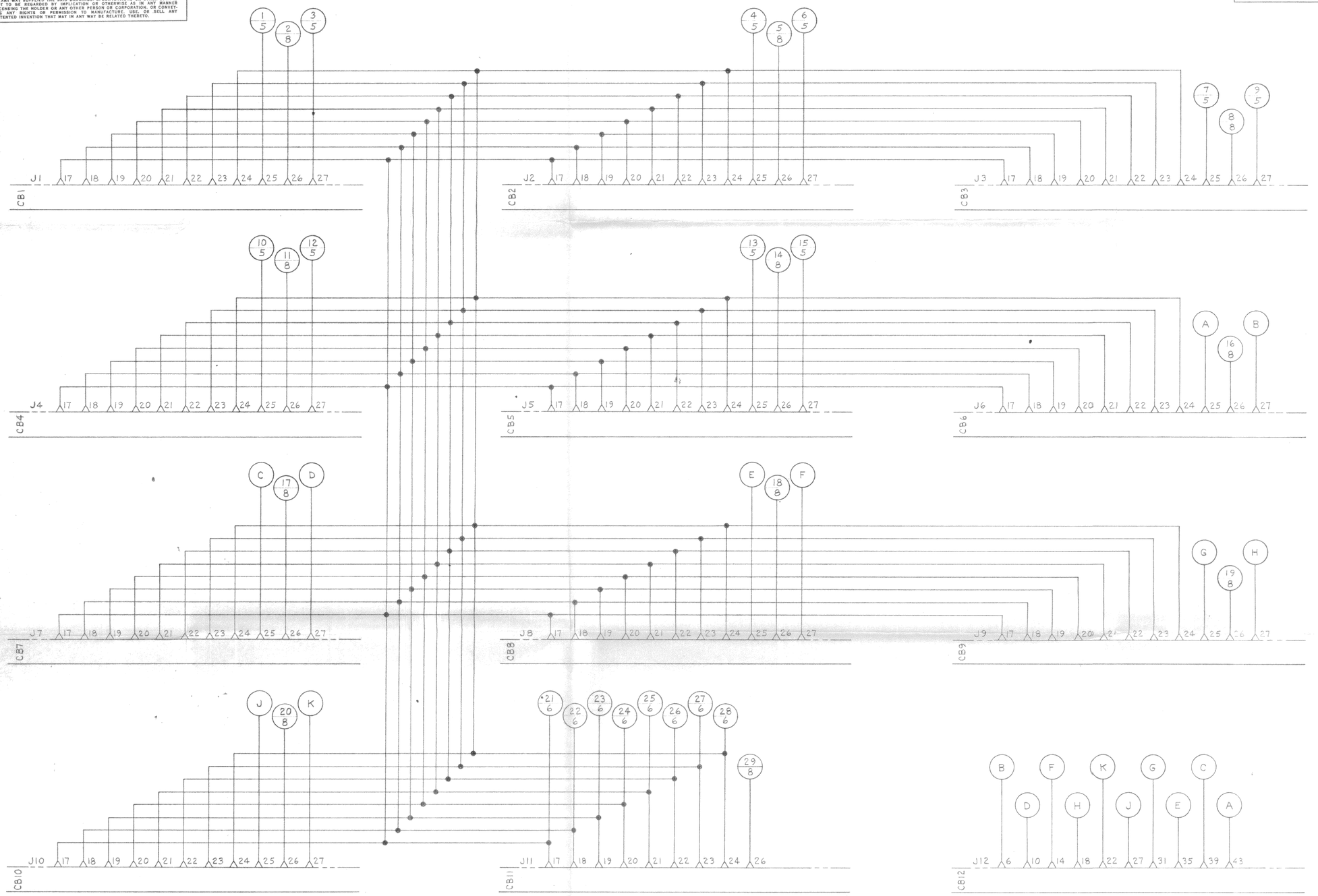


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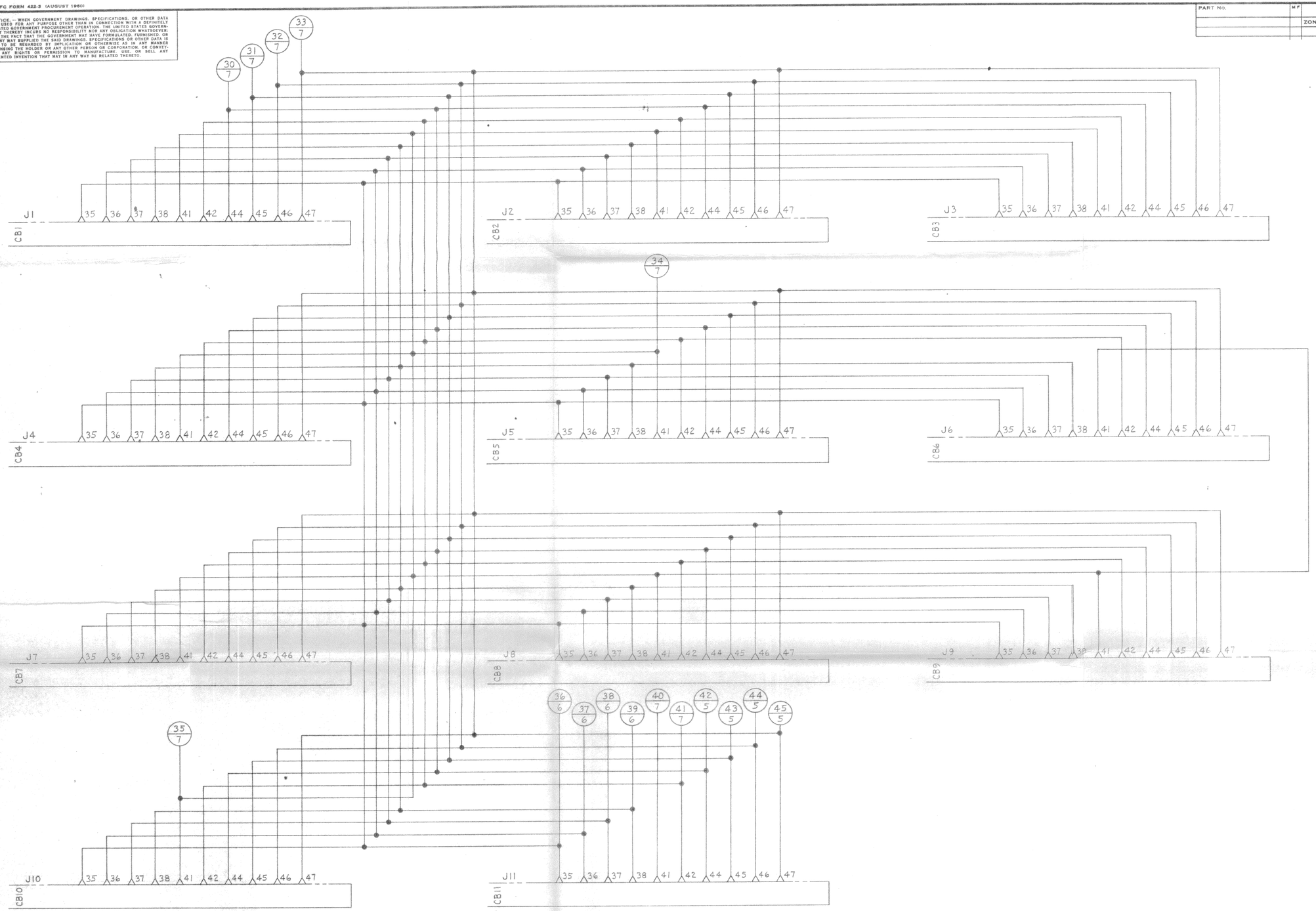
| | | DIMENSIONS ARE IN INCHES | DRAFTSMAN Williams / CHECKER | INTERCONNECTIONS | NATIONAL AERONAUTICS AND SPACE ADMINISTRATION |
| SEE ENGINEERING RECORDS | | TOLERANCES ON FRACTIONS DECIMALS ANGLES | CHECKER / STRESS | CB1 THRU CB12 | HUNTSVILLE, ALABAMA |
| | | | ENGINEER / ENGINEER | TUBE FLARE INSPECTION INSTR. | DWG SIZE D |
| | | MATERIAL | SUBMITTED | | |
| | | HEAT TREATMENT | APPROVED | WEIGHT CHECKER / DATE / CODE | SHEET 3 OF |
| NEXT ASSY | USED ON | FINAL PROTECTIVE FINISH | DIRECTOR | SCALE / UNIT WEIGHT | |
| APPLICATION | | | | | |

DISTR CODE

MSFC FORM 422-3 (AUGUST 1960)

NOTICE. -- WHEN GOVERNMENT DRAWINGS, SPECIFICATIONS, OR OTHER DATA ARE USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH A DEFINITELY RELATED GOVERNMENT PROCUREMENT OPERATION, THE UNITED STATES GOVERNMENT THEREBY INCURS NO RESPONSIBILITY NOR ANY OBLIGATION WHATSOEVER; AND THE FACT THAT THE GOVERNMENT MAY HAVE FORMULATED, FURNISHED, OR IN ANY WAY SUPPLIED THE SAID DRAWINGS, SPECIFICATIONS, OR OTHER DATA IS NOT TO BE REGARDED BY IMPLICATION OR OTHERWISE AS IN ANY MANNER LICENSING THE HOLDER OR ANY OTHER PERSON OR CORPORATION, OR CONVEYING ANY RIGHTS OR PERMISSION TO MANUFACTURE, USE, OR SELL ANY PATENTED INVENTION THAT MAY IN ANY WAY BE RELATED THERETO.

| PART NO. | M F | REVISIONS | | | | |
|---|---|---|---|---|---|---|
| | | ZONE | SYM | DESCRIPTION | DATE | APPROVAL |
| | | | | | | |



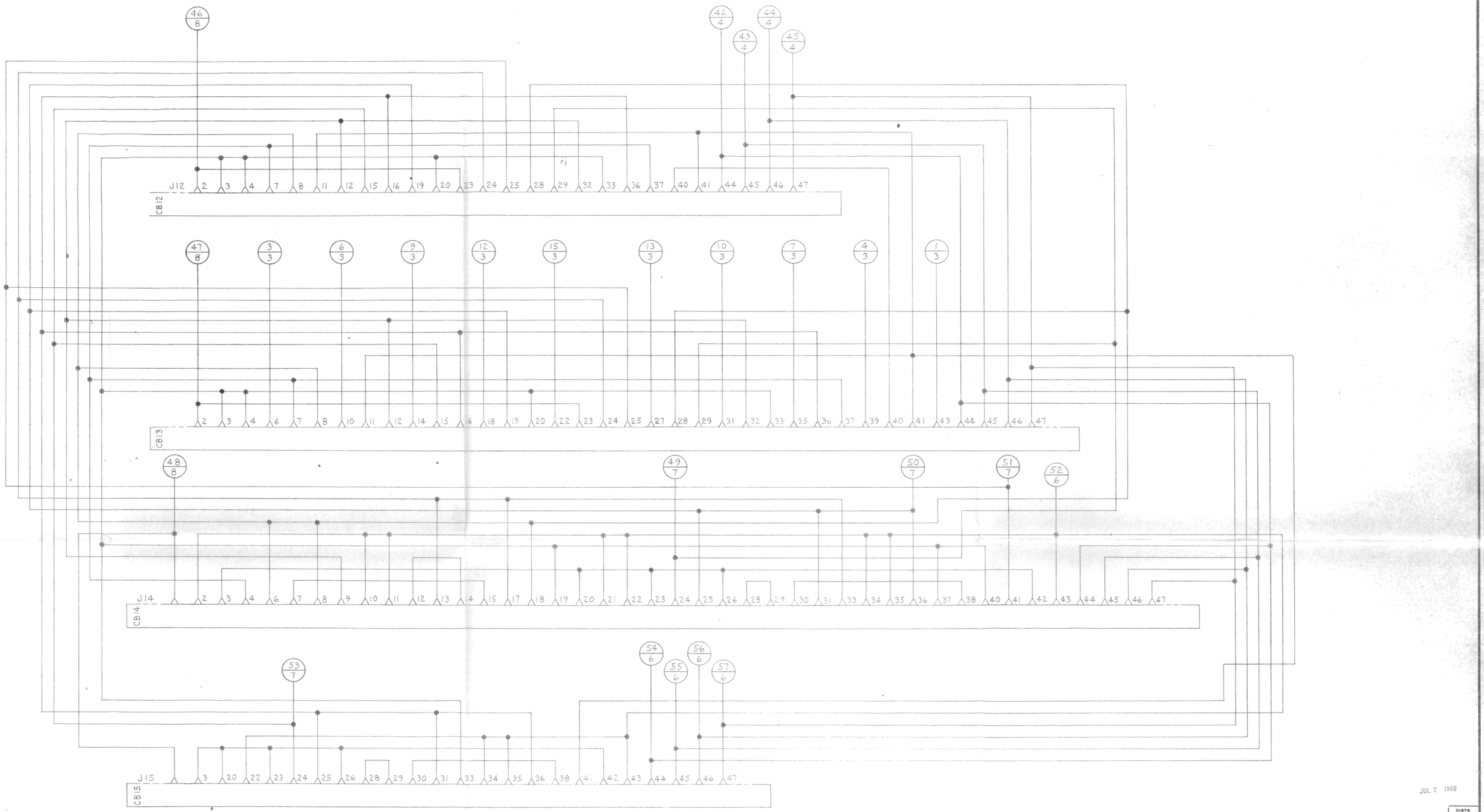

JUL 7 1966

| | | UNLESS OTHERWISE SPECIFIED | ORIGINAL DATE OF DRAWING | ADVANCED ELECTRICAL SCHEMATIC | GEORGE C. MARSHALL SPACE FLIGHT CENTER | DISTR CODE |
|---|---|---|---|---|---|---|
| | | DIMENSIONS ARE IN INCHES | DRAFTSMAN J. Kelley / CHECKER | INTERCONNECTIONS | NATIONAL AERONAUTICS AND SPACE ADMINISTRATION | |
| SEE ENGINEERING RECORDS | | TOLERANCES ON FRACTIONS DECIMALS ANGLES | CHECKER / STRESS | CB 1 THRU CB 11 | HUNTSVILLE, ALABAMA | |
| | | | ENGINEER / ENGINEER | TUBE FLARE INSPECTION INSTR. | DWG SIZE D | |
| | | MATERIAL | SUBMITTED | | | |
| NEXT ASSY | USED ON | HEAT TREATMENT | APPROVED | WEIGHT CHECKER / DATE / CODE | SHEET 4 OF | |
| APPLICATION | | FINAL PROTECTIVE FINISH | DIRECTOR | SCALE / UNIT WEIGHT | | |

MSFC FORM 422-3 (AUGUST 1960)

NOTICE.— WHEN GOVERNMENT DRAWINGS, SPECIFICATIONS, OR OTHER DATA ARE USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH A DEFINITELY RELATED GOVERNMENT PROCUREMENT OPERATION, THE UNITED STATES GOVERNMENT THEREBY INCURS NO RESPONSIBILITY NOR ANY OBLIGATION WHATSOEVER; AND THE FACT THAT THE GOVERNMENT MAY HAVE FORMULATED, FURNISHED, OR IN ANY WAY SUPPLIED THE SAID DRAWINGS, SPECIFICATIONS OR OTHER DATA IS NOT TO BE REGARDED BY IMPLICATION OR OTHERWISE AS IN ANY MANNER LICENSING THE HOLDER OR ANY OTHER PERSON OR CORPORATION, OR CONVEYING ANY RIGHTS OR PERMISSION TO MANUFACTURE, USE, OR SELL ANY PATENTED INVENTION THAT MAY IN ANY WAY BE RELATED THERETO.

| PART No. | M F | REVISIONS | | | | |
|---|---|---|---|---|---|---|
| | | ZONE | SYM | DESCRIPTION | DATE | APPROVAL |
| | | | | | | |




JUL 7 1966

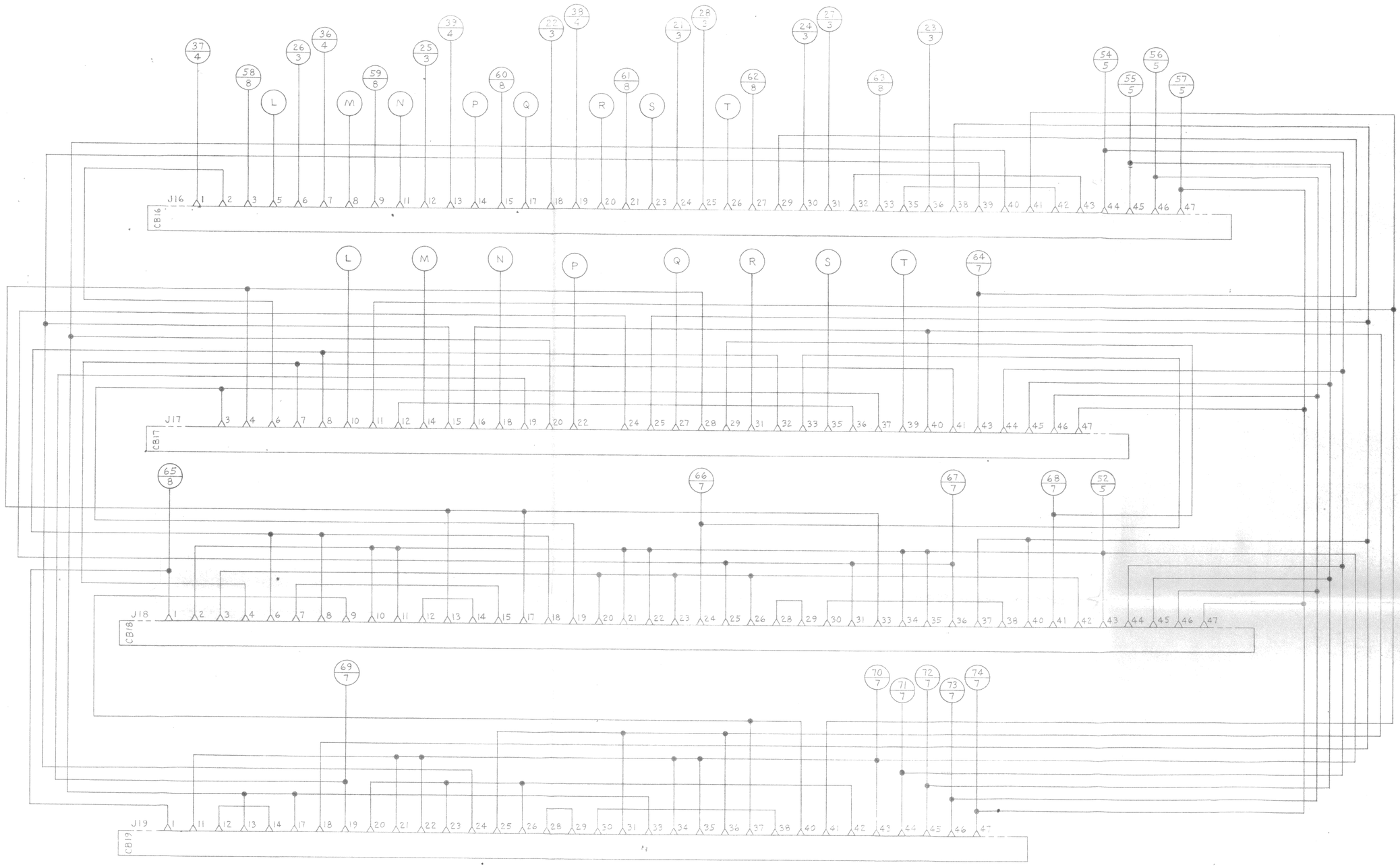
DISTR CODE

| | | UNLESS OTHERWISE SPECIFIED | ORIGINAL DATE OF DRAWING | ADVANCED ELECTRICAL SCHEMATIC | GEORGE C. MARSHALL SPACE FLIGHT CENTER |
|---|---|---|---|---|---|
| | | DIMENSIONS ARE IN INCHES<br>TOLERANCES ON FRACTIONS DECIMALS ANGLES | DRAFTSMAN Kelley CHECKER<br>CHECKER STRESS<br>ENGINEER ENGINEER | INTERCONNECTIONS<br>CB 12 THRU CB 15<br>TUBE FLARE INSPECTION INSTR | NATIONAL AERONAUTICS AND SPACE ADMINISTRATION<br>HUNTSVILLE, ALABAMA |
| SEE ENGINEERING RECORDS | | MATERIAL | SUBMITTED | | |
| | | HEAT TREATMENT | APPROVED | | DWG SIZE D |
| NEXT ASSY | USED ON | FINAL PROTECTIVE FINISH | DIRECTOR | WEIGHT CHECKER / DATE / CODE | SHEET 5 OF |
| APPLICATION | | | | SCALE / UNIT WEIGHT | |

MSFC FORM 422-3 (AUGUST 1960)

NOTICE. — WHEN GOVERNMENT DRAWINGS, SPECIFICATIONS, OR OTHER DATA ARE USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH A DEFINITELY RELATED GOVERNMENT PROCUREMENT OPERATION, THE UNITED STATES GOVERNMENT THEREBY INCURS NO RESPONSIBILITY NOR ANY OBLIGATION WHATSOEVER; AND THE FACT THAT THE GOVERNMENT MAY HAVE FORMULATED, FURNISHED, OR IN ANY WAY SUPPLIED THE SAID DRAWINGS, SPECIFICATIONS, OR OTHER DATA IS NOT TO BE REGARDED BY IMPLICATION OR OTHERWISE AS IN ANY MANNER LICENSING THE HOLDER OR ANY OTHER PERSON OR CORPORATION, OR CONVEYING ANY RIGHTS OR PERMISSION TO MANUFACTURE, USE, OR SELL ANY PATENTED INVENTION THAT MAY IN ANY WAY BE RELATED THERETO.

| PART No. | M F | REVISIONS | | | | |
|---|---|---|---|---|---|---|
| | | ZONE | SYM | DESCRIPTION | DATE | APPROVAL |
| | | | | | | |




JUL 7 1966

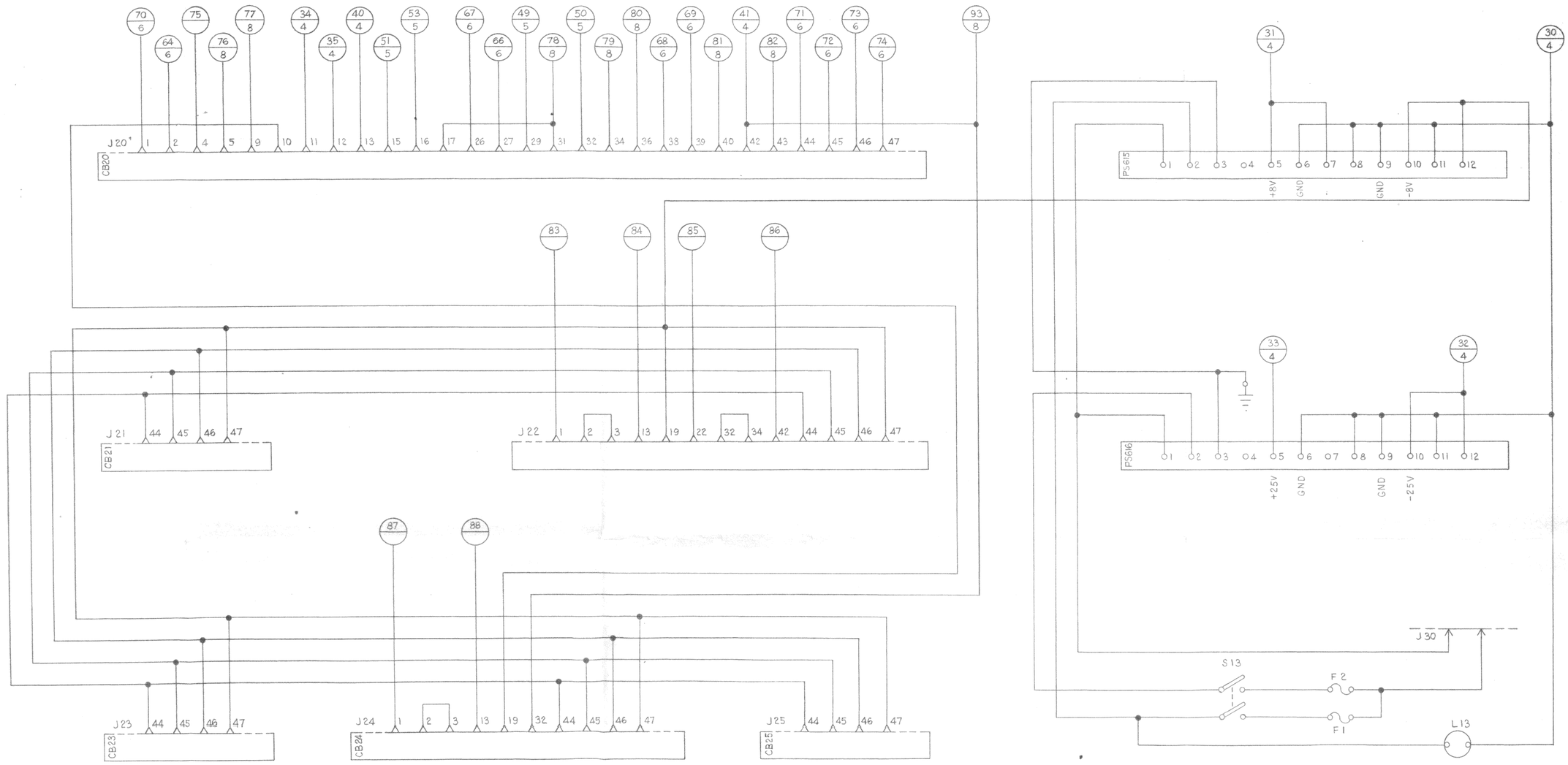
| | | | | | |
|---|---|---|---|---|---|
| | | UNLESS OTHERWISE SPECIFIED | ORIGINAL DATE OF DRAWING | ADVANCED ELECTRICAL SCHEMATIC | GEORGE C. MARSHALL SPACE FLIGHT CENTER |
| | | DIMENSIONS ARE IN INCHES | DRAFTSMAN R. Kay / CHECKER | INTERCONNECTIONS CB16 THRU CB19 | NATIONAL AERONAUTICS AND SPACE ADMINISTRATION |
| SEE ENGINEERING RECORDS | | TOLERANCES ON FRACTIONS DECIMALS ANGLES | CHECKER / STRESS | | HUNTSVILLE, ALABAMA |
| | | | ENGINEER / ENGINEER | TUBE FLARE INSPECTION INSTR | DWG SIZE D |
| NEXT ASSY | USED ON | MATERIAL | SUBMITTED | WEIGHT CHECKER / DATE / CODE | |
| APPLICATION | | HEAT TREATMENT | APPROVED | SCALE / UNIT WEIGHT | SHEET 6 OF |
| | | FINAL PROTECTIVE FINISH | DIRECTOR | | |

DISTR CODE

MSFC FORM 422-3 (AUGUST 1960)

NOTICE.—WHEN GOVERNMENT DRAWINGS, SPECIFICATIONS, OR OTHER DATA ARE USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH A DEFINITELY RELATED GOVERNMENT PROCUREMENT OPERATION, THE UNITED STATES GOVERNMENT THEREBY INCURS NO RESPONSIBILITY NOR ANY OBLIGATION WHATSOEVER; AND THE FACT THAT THE GOVERNMENT MAY HAVE FORMULATED, FURNISHED, OR IN ANY WAY SUPPLIED THE SAID DRAWINGS, SPECIFICATIONS OR OTHER DATA IS NOT TO BE REGARDED BY IMPLICATION OR OTHERWISE AS IN ANY MANNER LICENSING THE HOLDER OR ANY OTHER PERSON OR CORPORATION, OR CONVEYING ANY RIGHTS OR PERMISSION TO MANUFACTURE, USE, OR SELL ANY PATENTED INVENTION THAT MAY IN ANY WAY BE RELATED THERETO.

| PART NO. | M F | REVISIONS | | | | |
|---|---|---|---|---|---|---|
| | | ZONE | SYM | DESCRIPTION | DATE | APPROVAL |
| | | | | | | |



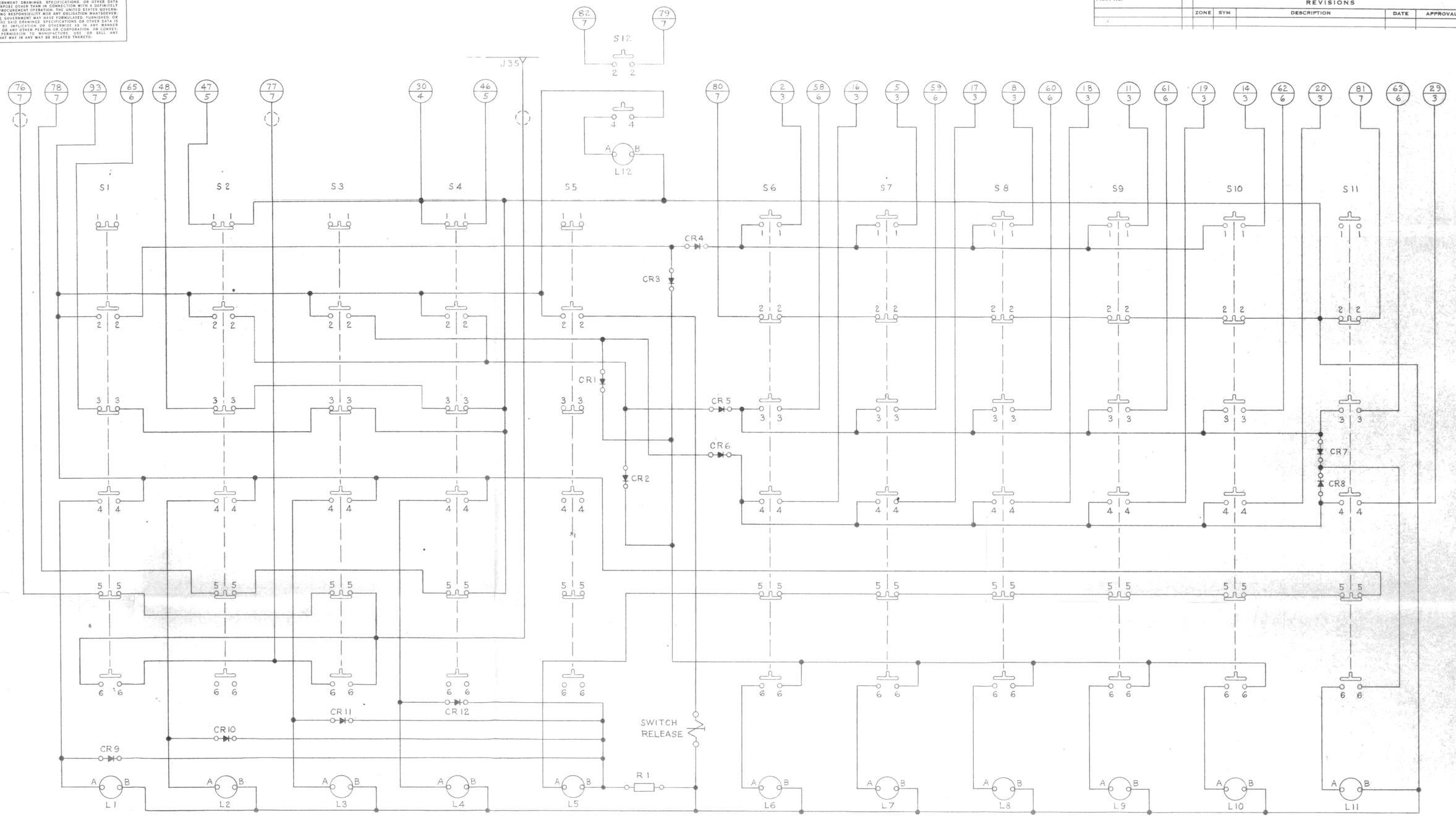

JUL 7 1966

| | | UNLESS OTHERWISE SPECIFIED | ORIGINAL DATE OF DRAWING | ADVANCED ELECTRICAL SCHEMATIC | GEORGE C. MARSHALL SPACE FLIGHT CENTER | DISTR CODE |
|---|---|---|---|---|---|---|
| | | DIMENSIONS ARE IN INCHES | DRAFTSMAN | INTERCONNECTIONS CB 20 THRU CB 25 AND POWER SUPPLIES | NATIONAL AERONAUTICS AND SPACE ADMINISTRATION | |
| SEE ENGINEERING RECORDS | | TOLERANCES ON FRACTIONS DECIMALS ANGLES | CHECKER | TUBE FLARE INSPECTION INSTR | HUNTSVILLE, ALABAMA | |
| | | | CHECKER STRESS | | DWG SIZE D | |
| | | MATERIAL | ENGINEER ENGINEER | | | |
| NEXT ASSY USED ON | | HEAT TREATMENT | SUBMITTED | WEIGHT CHECKER DATE CODE | SHEET 7 OF | |
| APPLICATION | | FINAL PROTECTIVE FINISH | APPROVED DIRECTOR | SCALE UNIT WEIGHT | | |

MBFC FORM 422-3 (AUGUST 1960)

NOTICE — WHEN GOVERNMENT DRAWINGS, SPECIFICATIONS, OR OTHER DATA ARE USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH A DEFINITELY RELATED GOVERNMENT PROCUREMENT OPERATION, THE UNITED STATES GOVERNMENT THEREBY INCURS NO RESPONSIBILITY NOR ANY OBLIGATION WHATSOEVER; AND THE FACT THAT THE GOVERNMENT MAY HAVE FORMULATED, FURNISHED, OR IN ANY WAY SUPPLIED THE SAID DRAWINGS, SPECIFICATIONS OR OTHER DATA IS NOT TO BE REGARDED BY IMPLICATION OR OTHERWISE AS IN ANY MANNER LICENSING THE HOLDER OR ANY OTHER PERSON OR CORPORATION OR CONVEYING ANY RIGHTS OR PERMISSION TO MANUFACTURE, USE OR SELL ANY PATENTED INVENTION THAT MAY IN ANY WAY BE RELATED THERETO.

| PART No. | MF | REVISIONS | | | | |
|---|---|---|---|---|---|---|
| | | ZONE | SYM | DESCRIPTION | DATE | APPROVAL |
| | | | | | | |




JUL 7 1966

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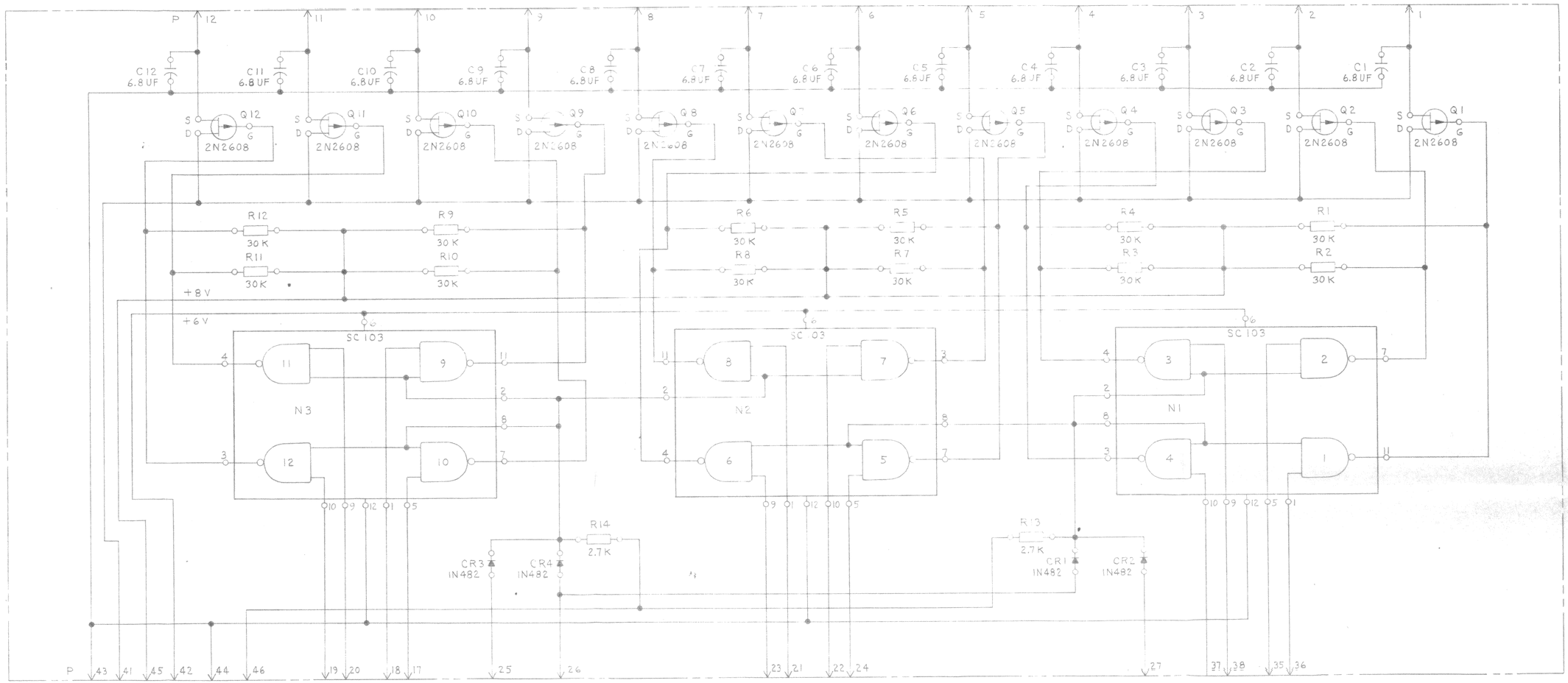
|---|---|---|---|---|---|
| SEE ENGINEERING RECORDS | | UNLESS OTHERWISE SPECIFIED<br>DIMENSIONS ARE IN INCHES<br>TOLERANCES ON FRACTIONS DECIMALS ANGLES<br>MATERIAL<br>HEAT TREATMENT<br>FINAL PROTECTIVE FINISH | ORIGINAL DATE OF DRAWING<br>DRAFTSMAN CHECKER<br>CHECKER STRESS<br>ENGINEER ENGINEER<br>SUBMITTED<br>APPROVED<br>DIRECTOR | ADVANCED ELECTRICAL SCHEMATIC<br>DISPLAY CONTROL SWITCHES<br>TUBE FLARE INPECTION INSTR | GEORGE C. MARSHALL SPACE FLIGHT CENTER<br>NATIONAL AERONAUTICS AND SPACE ADMINISTRATION<br>HUNTSVILLE, ALABAMA |
| NEXT ASSY | USED ON | | | WEIGHT CHECKER / DATE / CODE | DWG SIZE D |
| APPLICATION | | | | SCALE / UNIT WEIGHT | SHEET 8 OF |

DISTR CODE

MSFC FORM 422-3 (AUGUST 1960)

NOTICE. — WHEN GOVERNMENT DRAWINGS, SPECIFICATIONS, OR OTHER DATA ARE USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH A DEFINITELY RELATED GOVERNMENT PROCUREMENT OPERATION, THE UNITED STATES GOVERNMENT THEREBY INCURS NO RESPONSIBILITY NOR ANY OBLIGATION WHATSOEVER; AND THE FACT THAT THE GOVERNMENT MAY HAVE FORMULATED, FURNISHED, OR IN ANY WAY SUPPLIED THE SAID DRAWINGS, SPECIFICATIONS, OR OTHER DATA IS NOT TO BE REGARDED BY IMPLICATION OR OTHERWISE AS IN ANY MANNER LICENSING THE HOLDER OR ANY OTHER PERSON OR CORPORATION, OR CONVEYING ANY RIGHTS OR PERMISSION TO MANUFACTURE, USE, OR SELL ANY PATENTED INVENTION THAT MAY IN ANY WAY BE RELATED THERETO.

| PART No. | M F | REVISIONS | | | |
|---|---|---|---|---|---|
| | | ZONE | SYM | DESCRIPTION | DATE | APPROVAL |
| | | | | | | |




JUL 7 1966

DISTR CODE

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|---|---|---|---|---|---|
| SEE ENGINEERING RECORDS | | UNLESS OTHERWISE SPECIFIED<br>DIMENSIONS ARE IN INCHES<br>TOLERANCES ON FRACTIONS DECIMALS ANGLES | ORIGINAL DATE OF DRAWING<br>DRAFTSMAN Tilley CHECKER<br>CHECKER STRESS<br>ENGINEER ENGINEER | ADVANCED ELECTRICAL SCHEMATIC<br>COMMUTATOR PCB<br>CB I THRU CB II<br>TUBE FLARE INSPECTION INSTR. | GEORGE C. MARSHALL SPACE FLIGHT CENTER<br>NATIONAL AERONAUTICS AND SPACE ADMINISTRATION<br>HUNTSVILLE, ALABAMA |
| NEXT ASSY | USED ON | MATERIAL<br>HEAT TREATMENT<br>FINAL PROTECTIVE FINISH | SUBMITTED<br>APPROVED | WEIGHT CHECKER DATE CODE<br>SCALE UNIT WEIGHT | DWG SIZE D<br>SHEET 9 OF |
| APPLICATION | | | DIRECTOR | | |

MSFC FORM 422-3 (AUGUST 1960)

NOTICE — WHEN GOVERNMENT DRAWINGS, SPECIFICATIONS, OR OTHER DATA ARE USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH A DEFINITELY RELATED GOVERNMENT PROCUREMENT OPERATION, THE UNITED STATES GOVERNMENT THEREBY INCURS NO RESPONSIBILITY NOR ANY OBLIGATION WHATSOEVER; AND THE FACT THAT THE GOVERNMENT MAY HAVE FORMULATED, FURNISHED, OR IN ANY WAY SUPPLIED THE SAID DRAWINGS, SPECIFICATIONS OR OTHER DATA IS NOT TO BE REGARDED BY IMPLICATION OR OTHERWISE AS IN ANY MANNER LICENSING THE HOLDER OR ANY OTHER PERSON OR CORPORATION, OR CONVEYING ANY RIGHTS OR PERMISSION TO MANUFACTURE, USE, OR SELL ANY PATENTED INVENTION THAT MAY IN ANY WAY BE RELATED THERETO.

| PART NO. | M F | REVISIONS | | | | |
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| | | ZONE | SYM | DESCRIPTION | DATE | APPROVAL |
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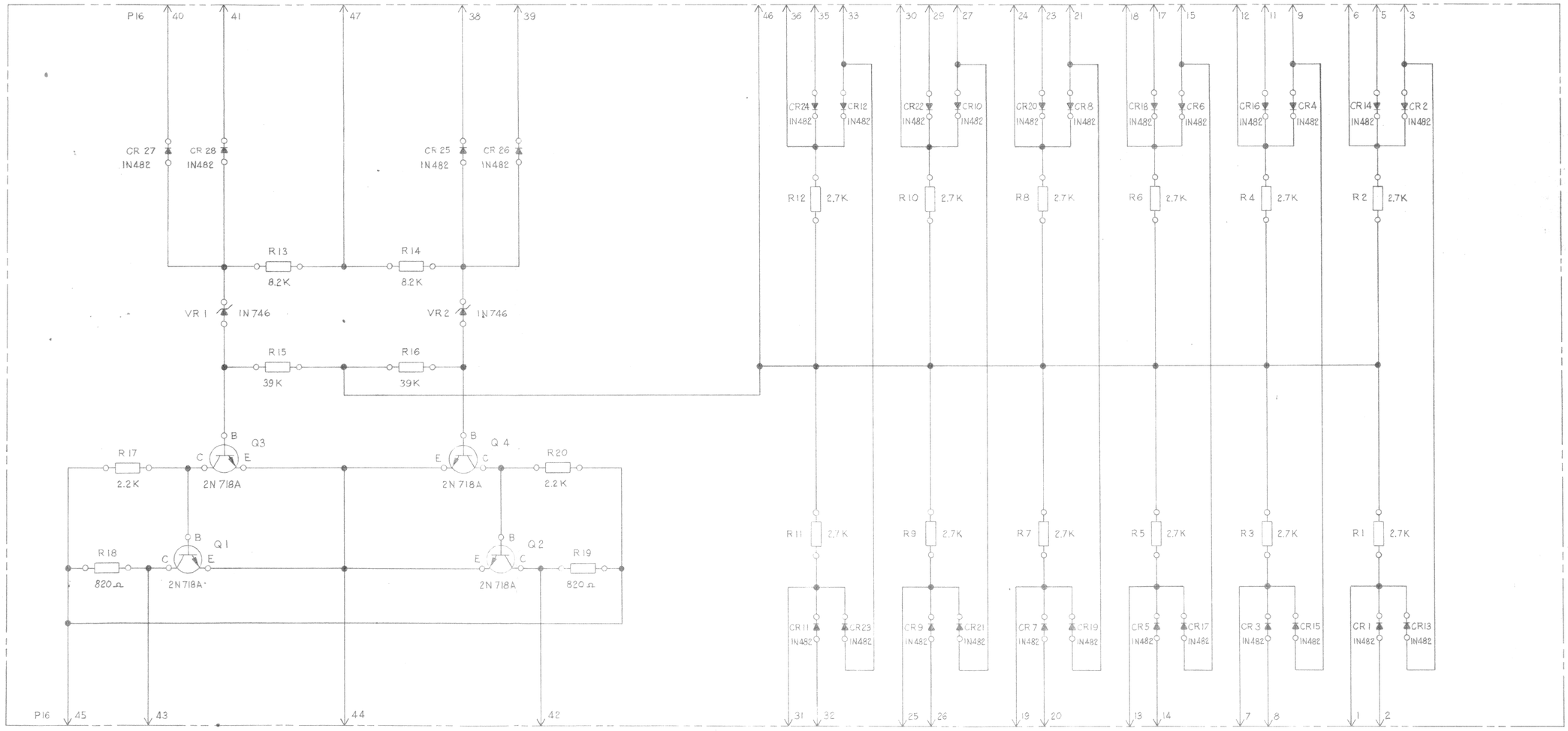


JUL 7 1966

DISTR CODE

| | | UNLESS OTHERWISE SPECIFIED | ORIGINAL DATE OF DRAWING | ADVANCED ELECTRICAL SCHEMATIC | GEORGE C. MARSHALL SPACE FLIGHT CENTER |
|---|---|---|---|---|---|
| | | DIMENSIONS ARE IN INCHES | | OR GATE PCB | NATIONAL AERONAUTICS AND SPACE ADMINISTRATION |
| SEE ENGINEERING RECORDS | | TOLERANCES ON FRACTIONS DECIMALS ANGLES | DRAFTSMAN CHECKER | CB 16 | HUNTSVILLE, ALABAMA |
| | | | CHECKER STRESS | TUBE FLARE INSPECTION INSTR | DWG SIZE D |
| | | MATERIAL | ENGINEER ENGINEER | | |
| | | HEAT TREATMENT | SUBMITTED | | |
| NEXT ASSY | USED ON | FINAL PROTECTIVE FINISH | APPROVED | WEIGHT CHECKER DATE CODE | SHEET 10 OF |
| APPLICATION | | | DIRECTOR | SCALE UNIT WEIGHT | |

MSFC FORM 422-3 (AUGUST 1960)

NOTICE.— WHEN GOVERNMENT DRAWINGS, SPECIFICATIONS, OR OTHER DATA ARE USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH A DEFINITELY RELATED GOVERNMENT PROCUREMENT OPERATION, THE UNITED STATES GOVERNMENT THEREBY INCURS NO RESPONSIBILITY NOR ANY OBLIGATION WHATSOEVER; AND THE FACT THAT THE GOVERNMENT MAY HAVE FORMULATED, FURNISHED, OR IN ANY WAY SUPPLIED THE SAID DRAWINGS, SPECIFICATIONS, OR OTHER DATA IS NOT TO BE REGARDED BY IMPLICATION OR OTHERWISE AS IN ANY MANNER LICENSING THE HOLDER OR ANY OTHER PERSON OR CORPORATION, OR CONVEYING ANY RIGHTS OR PERMISSION TO MANUFACTURE, USE, OR SELL ANY PATENTED INVENTION THAT MAY IN ANY WAY BE RELATED THERETO.

| PART No. | MF | REVISIONS | | | | |
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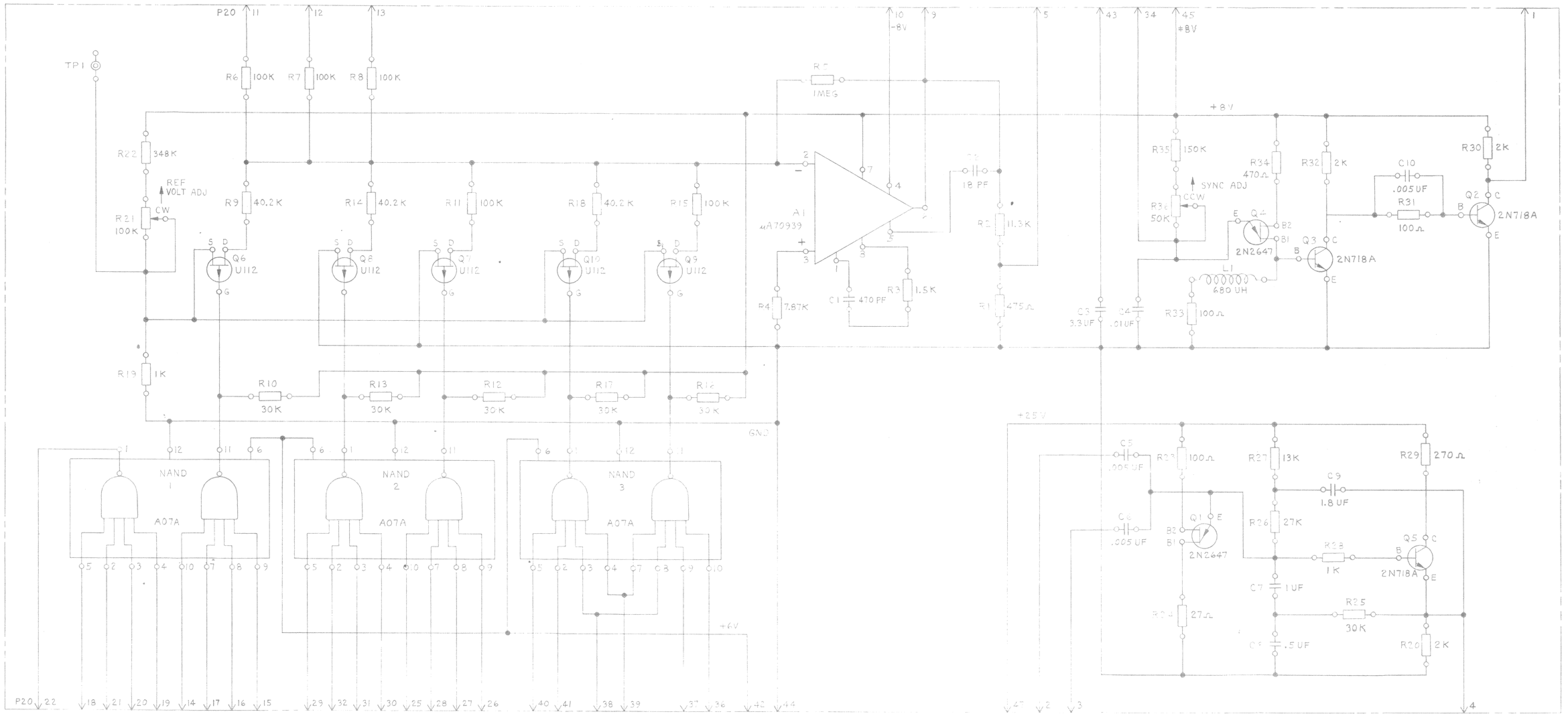
| | | ZONE | SYM | DESCRIPTION | DATE | APPROVAL |
| | | | | | | |




JUL 7 1966

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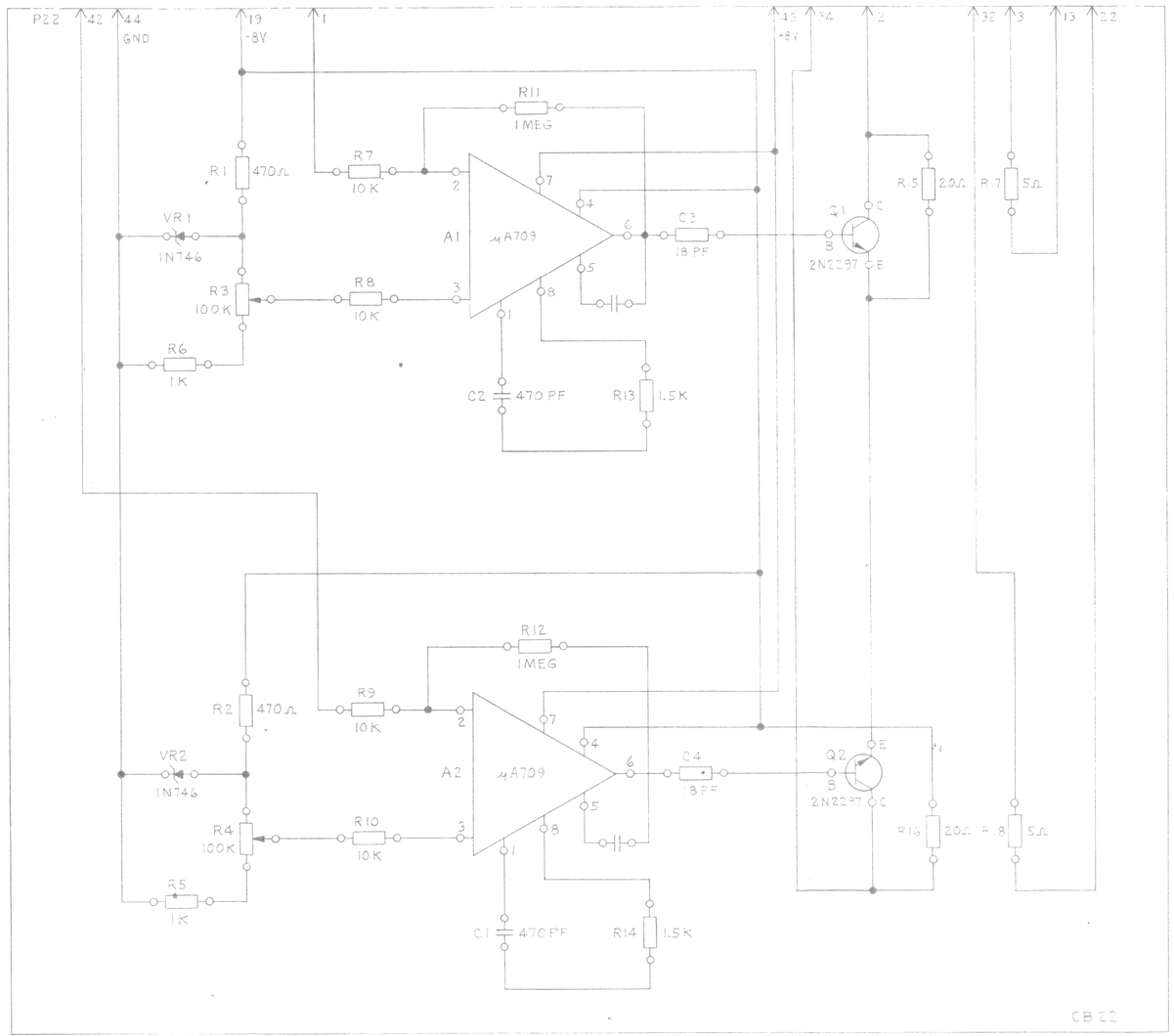
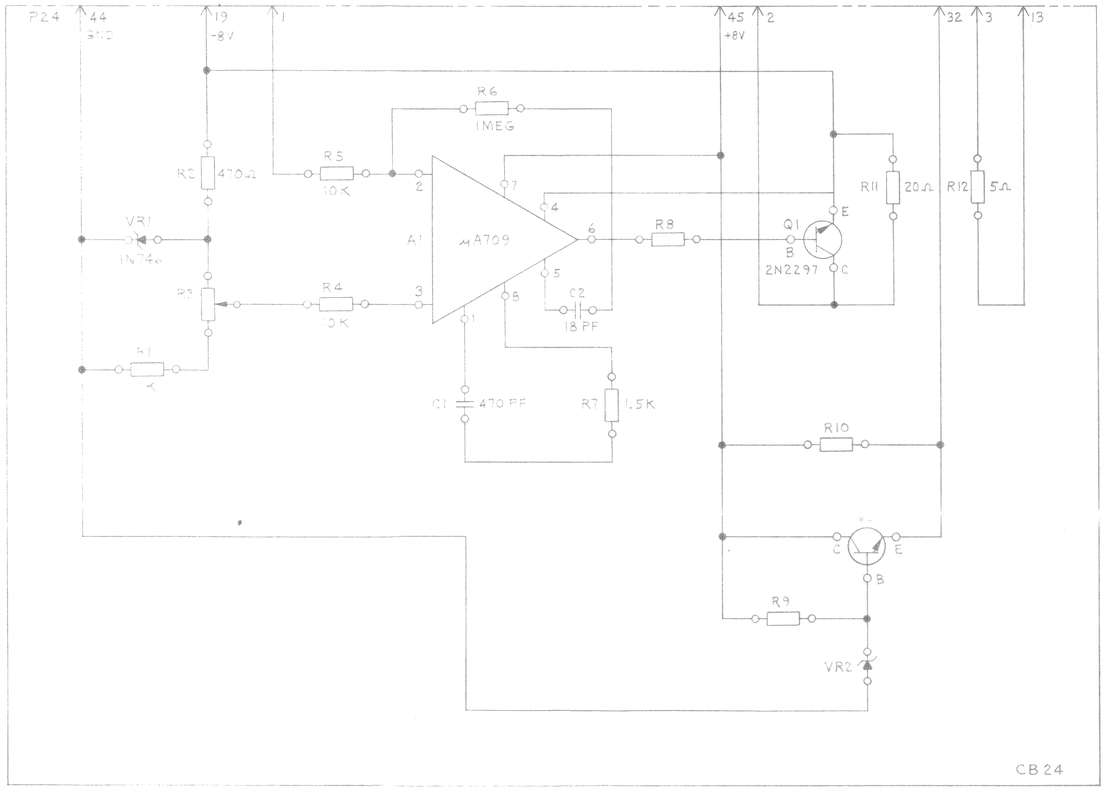
|---|---|---|---|---|---|
| SEE ENGINEERING RECORDS | | UNLESS OTHERWISE SPECIFIED<br>DIMENSIONS ARE IN INCHES<br>TOLERANCES ON FRACTIONS DECIMALS ANGLES | ORIGINAL DATE OF DRAWING<br>DRAFTSMAN Kirkley CHECKER<br>CHECKER STRESS<br>ENGINEER ENGINEER | ADVANCED ELECTRICAL SCHEMATIC<br>AMPLIFIER PCB, CB16<br>TUBE FLARE INSPECTION INSTR | GEORGE C. MARSHALL SPACE FLIGHT CENTER<br>NATIONAL AERONAUTICS AND SPACE ADMINISTRATION<br>HUNTSVILLE, ALABAMA |
| NEXT ASSY | USED ON | MATERIAL<br>HEAT TREATMENT<br>FINAL PROTECTIVE FINISH | SUBMITTED<br>APPROVED<br>DIRECTOR | WEIGHT CHECKER / DATE / CODE<br>SCALE / UNIT WEIGHT | DWG SIZE D<br>SHEET 11 OF |
| APPLICATION | | | | | DISTR CODE |

MSFC FORM 422-3 (AUGUST 1960)

NOTICE.—WHEN GOVERNMENT DRAWINGS, SPECIFICATIONS, OR OTHER DATA ARE USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH A DEFINITELY RELATED GOVERNMENT PROCUREMENT OPERATION, THE UNITED STATES GOVERNMENT THEREBY INCURS NO RESPONSIBILITY NOR ANY OBLIGATION WHATSOEVER; AND THE FACT THAT THE GOVERNMENT MAY HAVE FORMULATED, FURNISHED, OR IN ANY WAY SUPPLIED THE SAID DRAWINGS, SPECIFICATIONS, OR OTHER DATA IS NOT TO BE REGARDED BY IMPLICATION OR OTHERWISE AS IN ANY MANNER LICENSING THE HOLDER OR ANY OTHER PERSON OR CORPORATION, OR CONVEYING ANY RIGHTS OR PERMISSION TO MANUFACTURE, USE, OR SELL ANY PATENTED INVENTION THAT MAY IN ANY WAY BE RELATED THERETO.

| PART NO. | M F | REVISIONS | | | |
|---|---|---|---|---|---|
| | ZONE | SYM | DESCRIPTION | DATE | APPROVAL |
| | | | | | |



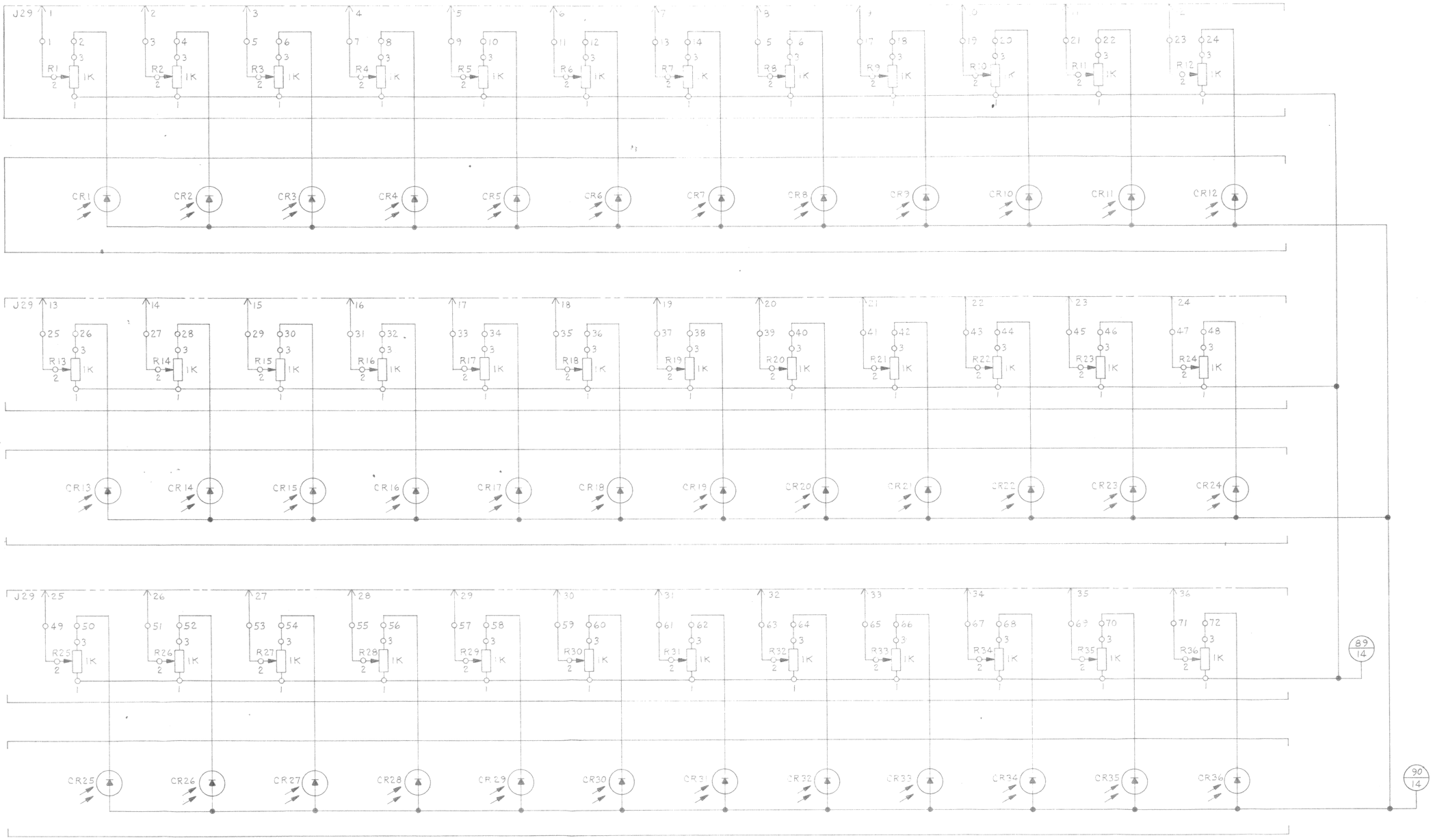

JUL 7 1966

| | | UNLESS OTHERWISE SPECIFIED | ORIGINAL DATE OF DRAWING | ADVANCED ELECTRICAL SCHEMATIC | GEORGE C. MARSHALL SPACE FLIGHT CENTER | DISTR CODE |
|---|---|---|---|---|---|---|
| | | DIMENSIONS ARE IN INCHES | DRAFTSMAN Billy CHECKER | LAMP REGULATOR | NATIONAL AERONAUTICS AND SPACE ADMINISTRATION | |
| SEE ENGINEERING RECORDS | | TOLERANCES ON FRACTIONS DECIMALS ANGLES | CHECKER STRESS | CB 22 AND CB24 | HUNTSVILLE, ALABAMA | |
| | | | ENGINEER ENGINEER | TUBE FLARE INSPECTION INSTR | DWG SIZE D | |
| | | MATERIAL | SUBMITTED | | | |
| NEXT ASSY | USED ON | HEAT TREATMENT | APPROVED | WEIGHT CHECKER DATE CODE | SHEET 12 OF | |
| APPLICATION | | FINAL PROTECTIVE FINISH | DIRECTOR | SCALE UNIT WEIGHT | | |

MSFC FORM 422-3 (AUGUST 1960)

NOTICE. — WHEN GOVERNMENT DRAWINGS, SPECIFICATIONS, OR OTHER DATA ARE USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH A DEFINITELY RELATED GOVERNMENT PROCUREMENT OPERATION, THE UNITED STATES GOVERNMENT THEREBY INCURS NO RESPONSIBILITY NOR ANY OBLIGATION WHATSOEVER; AND THE FACT THAT THE GOVERNMENT MAY HAVE FORMULATED, FURNISHED, OR IN ANY WAY SUPPLIED THE SAID DRAWINGS, SPECIFICATIONS OR OTHER DATA IS NOT TO BE REGARDED BY IMPLICATION OR OTHERWISE AS IN ANY MANNER LICENSING THE HOLDER OR ANY OTHER PERSON OR CORPORATION, OR CONVEYING ANY RIGHTS OR PERMISSION TO MANUFACTURE, USE, OR SELL ANY PATENTED INVENTION THAT MAY IN ANY WAY BE RELATED THERETO.

| PART NO. | M F | REVISIONS | | | |
|---|---|---|---|---|---|
| | ZONE | SYM | DESCRIPTION | DATE | APPROVAL |
| | | | | | |




JUL 7 1966

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|---|---|---|---|---|---|
| | | UNLESS OTHERWISE SPECIFIED | ORIGINAL DATE OF DRAWING | ADVANCED ELECTRICAL SCHEMATIC | GEORGE C. MARSHALL SPACE FLIGHT CENTER |
| SEE ENGINEERING RECORDS | | DIMENSIONS ARE IN INCHES<br>TOLERANCES ON FRACTIONS DECIMALS ANGLES | DRAFTSMAN CHECKER<br>CHECKER STRESS<br>ENGINEER ENGINEER | SIGNAL CONDITIONER & SENSORS, INSIDE FLARE TUBE FLARE INSPECTION INSTR | NATIONAL AERONAUTICS AND SPACE ADMINISTRATION<br>HUNTSVILLE, ALABAMA |
| | | MATERIAL | SUBMITTED | | |
| | | HEAT TREATMENT | APPROVED | | DWG SIZE D |
| NEXT ASSY | USED ON | FINAL PROTECTIVE FINISH | DIRECTOR | WEIGHT CHECKER / DATE / CODE | SHEET 13 OF |
| APPLICATION | | | | SCALE / UNIT WEIGHT | |

DISTR CODE

MSFC FORM 422-3 (AUGUST 1960)

NOTICE. — WHEN GOVERNMENT DRAWINGS, SPECIFICATIONS, OR OTHER DATA ARE USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH A DEFINITELY RELATED GOVERNMENT PROCUREMENT OPERATION, THE UNITED STATES GOVERNMENT THEREBY INCURS NO RESPONSIBILITY, NOR ANY OBLIGATION WHATSOEVER; AND THE FACT THAT THE GOVERNMENT MAY HAVE FORMULATED, FURNISHED, OR IN ANY WAY SUPPLIED THE SAID DRAWINGS, SPECIFICATIONS OR OTHER DATA IS NOT TO BE REGARDED BY IMPLICATION OR OTHERWISE AS IN ANY MANNER LICENSING THE HOLDER OR ANY OTHER PERSON OR CORPORATION, OR CONVEYING ANY RIGHTS OR PERMISSION TO MANUFACTURE, USE, OR SELL ANY PATENTED INVENTION THAT MAY IN ANY WAY BE RELATED THERETO.

| PART NO. | NF | REVISIONS | | | | |
|---|---|---|---|---|---|---|
| | | ZONE | SYM | DESCRIPTION | DATE | APPROVAL |
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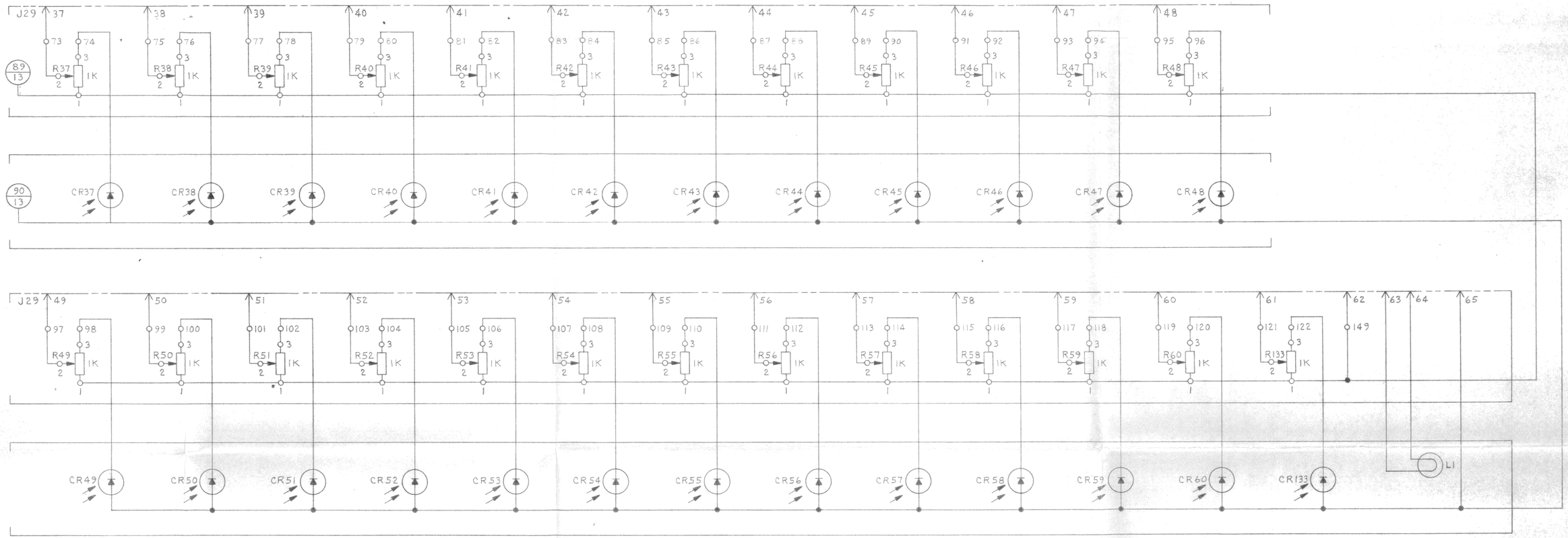


JUL 7 1966

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|---|---|---|---|---|---|
| | | UNLESS OTHERWISE SPECIFIED | ORIGINAL DATE OF DRAWING | ADVANCED ELECTRICAL SCHEMATIC | GEORGE C. MARSHALL SPACE FLIGHT CENTER |
| SEE ENGINEERING RECORDS | | DIMENSIONS ARE IN INCHES<br>TOLERANCES ON FRACTIONS DECIMALS ANGLES | DRAFTSMAN Gilley CHECKER<br>CHECKER STRESS<br>ENGINEER ENGINEER | SIGNAL CONDITIONER & SENSORS, INSIDE FLARE<br>TUBE FLARE INSPECTION INSTR | NATIONAL AERONAUTICS AND SPACE ADMINISTRATION<br>HUNTSVILLE, ALABAMA |
| | | MATERIAL | SUBMITTED | | DWG SIZE D |
| | | HEAT TREATMENT | APPROVED | WEIGHT CHECKER DATE CODE | |
| NEXT ASSY | USED ON | FINAL PROTECTIVE FINISH | DIRECTOR | SCALE UNIT WEIGHT | SHEET 14 OF |
| APPLICATION | | | | | DISTR CODE |

MSFC FORM 422-3 (AUGUST 1980)

NOTICE — WHEN GOVERNMENT DRAWINGS, SPECIFICATIONS, OR OTHER DATA ARE USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH A DEFINITELY RELATED GOVERNMENT PROCUREMENT OPERATION, THE UNITED STATES GOVERNMENT THEREBY INCURS NO RESPONSIBILITY NOR ANY OBLIGATION WHATSOEVER; AND THE FACT THAT THE GOVERNMENT MAY HAVE FORMULATED, FURNISHED, OR IN ANY WAY SUPPLIED THE SAID DRAWINGS, SPECIFICATIONS, OR OTHER DATA IS NOT TO BE REGARDED BY IMPLICATION OR OTHERWISE AS IN ANY MANNER LICENSING THE HOLDER OR ANY OTHER PERSON OR CORPORATION, OR CONVEYING ANY RIGHTS OR PERMISSION TO MANUFACTURE, USE, OR SELL ANY PATENTED INVENTION THAT MAY IN ANY WAY BE RELATED THERETO.

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| | | ZONE | SYM | DESCRIPTION | DATE | APPROVAL |
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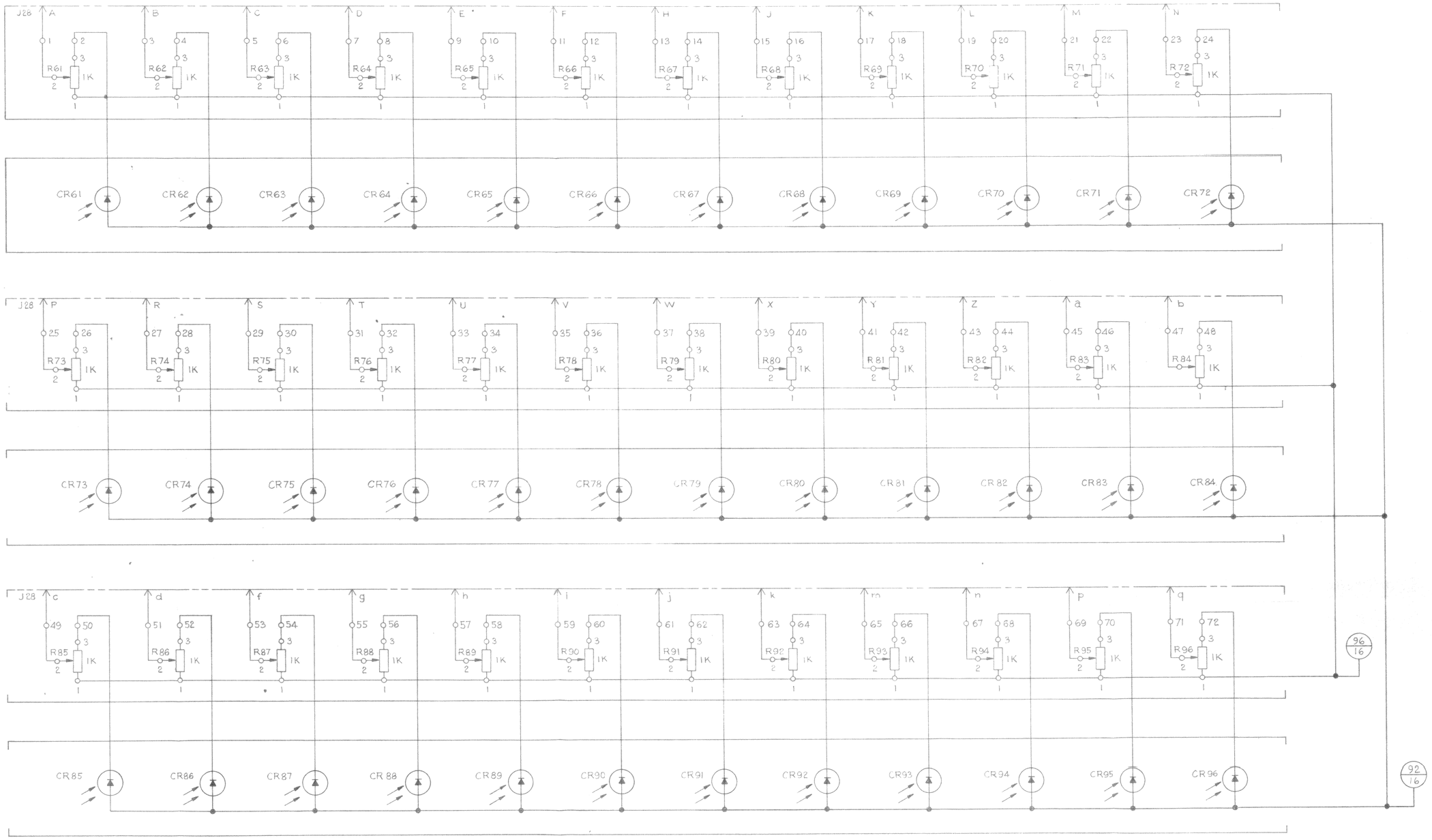


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| SEE ENGINEERING RECORDS | | UNLESS OTHERWISE SPECIFIED<br>DIMENSIONS ARE IN INCHES<br>TOLERANCES ON FRACTIONS DECIMALS ANGLES | ORIGINAL DATE OF DRAWING<br>DRAFTSMAN CHECKER<br>CHECKER STRESS<br>ENGINEER ENGINEER | ADVANCED ELECTRICAL SCHEMATIC<br>SIGNAL CONDITIONER & SENSORS, OUTSIDE FLARE<br>TUBE FLARE INSPECTION INSTR |
| | | MATERIAL | SUBMITTED | |
| | | HEAT TREATMENT | APPROVED | |
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| APPLICATION | | | | |

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HUNTSVILLE, ALABAMA

DWG SIZE D

| WEIGHT CHECKER | DATE | CODE | SCALE | UNIT WEIGHT | SHEET 15 OF |
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MSFC FORM 422-3 (AUGUST 1960)

NOTICE. — WHEN GOVERNMENT DRAWINGS, SPECIFICATIONS, OR OTHER DATA ARE USED FOR ANY PURPOSE OTHER THAN IN CONNECTION WITH A DEFINITELY RELATED GOVERNMENT PROCUREMENT OPERATION, THE UNITED STATES GOVERNMENT THEREBY INCURS NO RESPONSIBILITY NOR ANY OBLIGATION WHATSOEVER; AND THE FACT THAT THE GOVERNMENT MAY HAVE FORMULATED, FURNISHED, OR IN ANY WAY SUPPLIED THE SAID DRAWINGS, SPECIFICATIONS, OR OTHER DATA IS NOT TO BE REGARDED BY IMPLICATION OR OTHERWISE AS IN ANY MANNER LICENSING THE HOLDER OR ANY OTHER PERSON OR CORPORATION, OR CONVEYING ANY RIGHTS OR PERMISSION TO MANUFACTURE, USE, OR SELL ANY PATENTED INVENTION THAT MAY IN ANY WAY BE RELATED THERETO.

| PART NO. | M F | REVISIONS | | | | |
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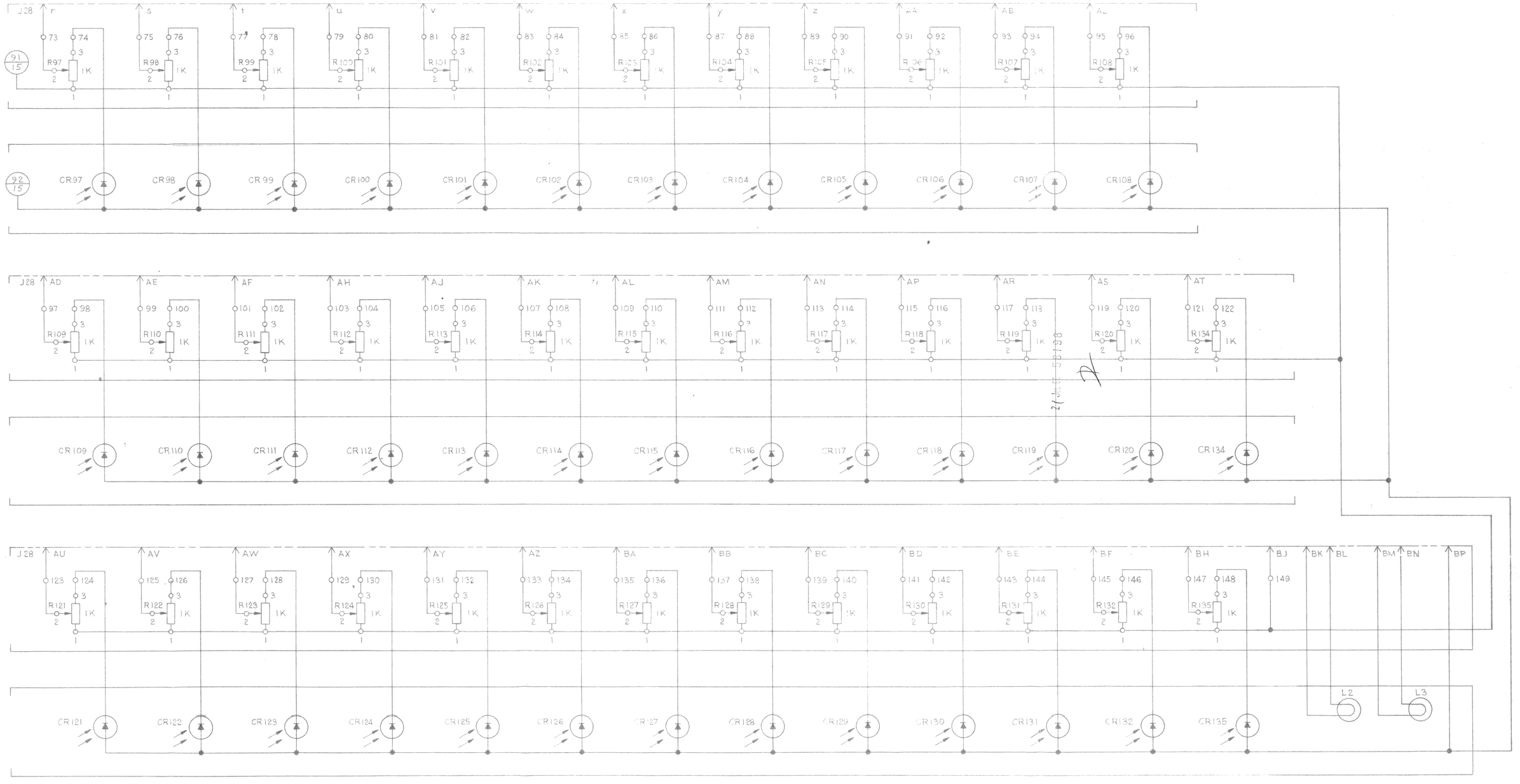


JUL 7 1966

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| SEE ENGINEERING RECORDS | | UNLESS OTHERWISE SPECIFIED<br>DIMENSIONS ARE IN INCHES<br>TOLERANCES ON FRACTIONS DECIMALS ANGLES | ORIGINAL DATE OF DRAWING<br>DRAFTSMAN CHECKER<br>CHECKER STRESS<br>ENGINEER ENGINEER | ADVANCED ELECTRICAL SCHEMATIC<br>SIGNAL CONDITIONER & SENSORS, OUTSIDE FLARE<br>TUBE FLARE INSPECTION INSTR | GEORGE C. MARSHALL SPACE FLIGHT CENTER<br>NATIONAL AERONAUTICS AND SPACE ADMINISTRATION<br>HUNTSVILLE, ALABAMA |
| NEXT ASSY | USED ON | MATERIAL | SUBMITTED | | DWG SIZE D |
| APPLICATION | | HEAT TREATMENT<br>FINAL PROTECTIVE FINISH | APPROVED<br>DIRECTOR | WEIGHT CHECKER DATE CODE<br>SCALE UNIT WEIGHT | SHEET 16 OF |

DISTR CODE